Subterranea

The Magazine for Subterranea Britannica

Subterranea Britannica **August 2020 Issue 54**

IN THIS ISSUE

Tunnels of Corregidor
Paddock bunker at Dollis Hill
Hardham canal tunnel
Robben Island plotting rooms

Subterranea Britannica is a society devoted to the study of man-made and man-used underground structures and the archaeology of the Cold War. The society is open to all and its membership includes all walks of life.
Members are invited to contribute to this magazine even if this just means sending very welcome snippets from newspapers and magazines.
Contributors to *Subterranea* also give their permission for articles and images to be reproduced on Sub Brit's website.

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Front cover photo: *Standby generator on the lower floor of the WWII standby Cabinet war room (Paddock) in Brook Road, Dollis Hill, north-west London. This bunker would have been activated if the Cabinet War Room in Central London had been taken out of use due to enemy action. The control cabinet for the generator is on the left with ventilation plant on the right. When the bunker was first entered by members of Subterranea Britannica in May 2001 the water in this room was 16 inches deep. When public tours started a year later the water had been pumped out and the bunker is kept relatively dry by continuous pumping. Photo Nick Catford*

Back page upper: *Narrowboat* Dragonfly *with your outgoing Chairman Martin Dixon at the helm emerging from the south portal of the Harecastle canal tunnel built by Telford. The white chains indicate the lowest profile of the tunnel which has reduced over the years due to subsidence. These chains have now been replaced by a fixed profile board as part of safety improvements following a fatality in 2014 when a boater was knocked overboard in the lowest section of the tunnel. The building surrounding the portal contains fans for ventilation purposes. See book review Harecastle's Canal and Railway Tunnels on page 15. Photo Linda Dixon*

Back page lower: *In late 1940 the Sector Operations Centre for 10 Group RAF (Box) was relocated from Rudloe Manor to two large underground chambers at the north end of Browns Quarry, Corsham. The two chambers were stripped of all original fixtures and fittings in the late 1980s. This is a view from the Sector Operations Room looking into the Filter Room in 2008. Photo Nick Catford*

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The committee of Subterranea Britannica and the Editor do not necessarily agree with any views expressed and cannot always check the accuracy of any material sent in.

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Chairman's Welcome - and Farewell

Martin Dixon

Welcome once again to another edition of *Subterranea*. It's nice to have something familiar to keep us grounded in these strange times. As I write this in early July, week by week restrictions are gradually being lifted but I feel it will be a long time before normality as we once knew it returns. My sympathy goes to all members who have been impacted in whatever way by Covid-19 and my heartfelt thanks to those who have continued providing vital services to us all during lockdown.

Special thanks to those who have helped Sub Brit keep going. A number of members responded to requests for articles for *Subterranea* and you'll find some of them within these pages. It's always a pleasure to see new authors and to read about new sites. This time we feature sites from as far away as Antarctica, South Africa and the Philippines as well as those closer to home.

I'm sure we are all hugely grateful to those who have helped set up and run what have become our regular online presentations or webinars. Tony Radstone and Richard Seabrook have made the arrangements and we should also thank all those who have given talks. It reinforces the enormous breadth of expertise and knowledge across our membership. We've had some brilliant sessions but from a personal level I'm really missing the opportunity to socialise with other members. Video links can obviously help but I'm looking forward to being able to share a drink in person – my round!

Sub Brit's membership is slightly down on this time last year. If any readers can encourage others to join our great society, that would be much appreciated. A number of our expenses (web fees, insurance etc) are largely fixed, so increased membership helps defray these costs. Plus we get preferential mailing rates when our membership hits 1,000 UK addresses (we're a whisker short at present) which helps reduce the cost of mailing *Subterranea*. And, of course, new members bring new perspectives and help secure our future.

Since the last edition, the Committee has approved two sizeable grants. The first is to the Wealden Cave and Mine Society to provide an alternative exit route from Reigate's West Side 'Caves'; this will allow their splendid public tours to continue into the future.

The second is to Maidstone Grammar School for Girls, towards the cost of reopening a newly discovered WWII air-raid shelter that will be used for teaching and for wider education. It's great to be able to help projects such as these – largely funded by Gift Aid. It takes the total donated since we became a charity to over £50,000.

Finally, this will be my last column as Chairman. I'm stepping down as I need some medical treatment and as a result I'm not able to devote sufficient time and energy to Sub Brit at present. I'm grateful to Tim Wellburn who, as our Vice Chair, has taken over running Sub Brit and to other members of the Committee who have helped reduce my inbox and workload. I hope to stay on as a Committee member – to be ratified at what is planned to be a virtual AGM later this year.

I've massively enjoyed my time as Chairman over the past 13 years and in particular to having been able to share my passion for the underground with so many others in the UK and overseas. One of the delights of Sub Brit is the wide range of backgrounds of fellow members – all of whom willingly share their knowledge with others. I look forward to being able to meet up again and to explore the hidden gems that provide us with so much fascination.

mdixon@subbrit.org.uk

The west side caves in Tunnel Road, Reigate. Sub Brit is providing funds to construct an alternative exit. Photo Nick Catford

Index of *Subterranea* magazine issues 1-50

Linda Dixon

Please find enclosed with this edition of ***Subterranea*** the consolidated Index of Issues 1-50. The first issue was back in 2003, and with roughly 60 pages per issue, that's about 3,000 pages of information about underground sites. On average there are eight main articles per issue, so that's a whopping 400 pieces of in-depth information published as an archive – in fact, even more than 400, if you take into account the News sections.

The Index will also be available on our Members' Forum; this version has additional Keywords, giving more detail about the sites in the articles. This version will be fully searchable, so hopefully you can find the site you are interested in. Much of the site information is also finding its way onto the main website.

If you would like any of the previous issues of ***Subterranea*** then email us at publications@subbrit.org.uk, telling us which issue(s) you would like and who/where to send them to.
Issues are priced to include Post and Packing as follows: 41-50 at £5 each, 31-40 at £4, 21-30 at £3 and 1-20 at £2.

If your insert is missing and you would like one, please contact us at 'publications@subbrit.org.uk' or by post to our registered address.

Summary Minutes of Sub Brit Committee Meeting - held online 27 June 2020

Due to the Covid-19 restrictions, the Committee decided to hold the meeting online, which worked successfully.

Participating: Tim Wellburn (in the Chair), Phil Catling, Chris Gray, Tony Radstone, Richard Seabrook, Bob Templeman, Richard West.

Apologies for absence from Jason Hughes and Martin and Linda Dixon. Martin Dixon has stepped down as Chairman on medical grounds.

Matters arising from last meeting As a result of the government's Coronavirus restrictions occurring from February 2020 to date, the following actions were taken. Refunds to members were offered, as appropriate.

- Cancellation of Spring Day Meeting and AGM on 25 April
- Postponement of Crossness visit on 26 April
- Postponement of AGM until October, alongside Autumn Meeting if possible
- Cancellation of SB study weekend to Oslo, scheduled for May
- Postponement of Tony's visit to Dumpy level at Dover to 14 March 2021
- Postponement of extended Post Office Railway walk

Membership The Committee discussed ways of retaining and recruiting members. Ideally we would like to keep at least 1000 members as this saves significant cost on the mailing of ***Subterranea.*** We agreed to re-contact those people whose membership had lapsed. We agreed to try to recruit non-members who had watched one of our '*In the Dark' Webinars.* We will also look at a special membership deal for students.

"In The Dark" Webinars Thanks were given to Tony and Richard S for championing these new online seminars for SB members, which are also available to the general public. There has been a good response to those presentations which have taken place so far – thanks to those who have volunteered to speak.

Autumn 2020 Meeting & Visits programme Our Northamptonshire weekend for 17/18 October has regrettably been cancelled due to Covid-19 restrictions. It will be rescheduled for October 2021.

Spring Meeting 2021 was set as **27 March;** we will hope to book London Metropolitan University.

Annual General Meeting 2020 We agreed to hold this year's postponed AGM online at 10:00hrs on **Saturday 31 October 2020**, using 'Google Meet' as the platform. Members will be informed in due course and the Agenda will be posted on the SB website.

Trips and visits Various thoughts are being progressed, mostly for 2021, when we hope the Covid-19 pandemic restrictions will be reduced enough for these to take place.

Reports from Committee Officers: posted online, no matters arising. Key points to note:

- Grants of £5,000 each agreed to Reigate West Side Caves (to help provide a second exit from the caves, as required by the Mines Inspectorate); and to Maidstone Grammar School for Girls (towards the cost of reopening a newly discovered WWII air-raid shelter that will be used for teaching). Other grants are pending.
- The Trustees' Report is now filed alongside the report and accounts with Companies House and the Charity Commission.
- Following the successful online webinars it is hoped that we may be able to increase use of this medium post-lockdown.

Next Committee meeting: Saturday 24 October 2020 – Online.

Subterranea Britannica

Notice of Annual General Meeting 2020

The AGM will be held on Saturday 31 October 2020,
commencing at 10:00am

The meeting will be held online

Registration information will be advised to members beforehand

This date replaces the Spring Meeting date originally notified for the AGM,
the rescheduling being necessitated by Covid-19 restrictions

Attendance is open to all current members of Subterranea Britannica

Documents for the AGM will be available on our website at **www.subbrit.org.uk**
at least 28 days in advance of the meeting

Documents will be sent to those members who have registered to receive them by post

Minutes of the AGM 2019 were printed in *Subterranea* Issue 51, August 2019

AUTUMN 2020 STUDY WEEKEND RESCHEDULED TO 2021

As advised by e-mail and notified on the Forum in July, the Committee reluctantly took the decision to cancel the planned 2020 Autumn Study Weekend.

The continuing uncertainty around the coronavirus pandemic and related restrictions rendered the programme untenable, and an orderly rescheduling of the event seemed preferable to continuing to await developments and risk a more disruptive late abandonment.

The good news is that we have made arrangements to secure all the intended speakers and proposed site visits to deliver the same programme at Sywell a year hence, in Autumn 2021.

Likewise, the intended speaker programme for this year's cancelled Spring Meeting has been rebooked for next year's Spring Meeting. This will be held at Canada Water Library in south London on 27 March 2021: please hold the date in your diaries! Normal booking arrangements will be put in place nearer the time.

Our **Annual General Meeting**, postponed from April this year, will now be held online on the morning of **Saturday 31 October**. We do not anticipate a long meeting and would be grateful for your support in attending. Details about this will be notified nearer the time.

All these changes have created much extra work for the Committee and volunteer organisers, to whom sincere thanks are due.

I look forward to seeing many of you online at the AGM on 31 October, and in person at the Spring Day Conference on 27 March 2021.

Tim Wellburn

SUBTERRANEA BRITANNICA DIARY

Summary of Forthcoming Events

Sub Brit specific events

24 October 2020 Committee Meeting – Online

31 October 2020 Annual General Meeting – Online – 10:00hrs

01 November 2020 Copy deadline for *Subterranea* 55

Mid-December *Subterranea* 55 published

2021

16 January 2021 Committee Meeting – Online

01 March 2021 Copy deadline for *Subterranea* 56

14 March 2021 Visit to Dumpy Level, Dover (Visit #1)

27 March 2021 Spring Meeting & AGM, Canada Water, south London

30 April 2021 *Subterranea* 56 published

Other underground-related events

11 - 20 September Heritage Open Days, England

14 - 20 September Glasgow Doors Open Days - Mainly Digital

19 - 20 September Open House London

Weekends in September Doors Open Days, Scotland - Mainly Digital

Status tbc Open Doors, Wales

2021

29 May – 5 June 2021 FSG Sweden Tour

For web links to these events please visit *www.subbrit.org.uk/events*
or contact the organisation concerned

If you know of other relevant events run by other societies, please let us know so that they can be advertised in the next edition and on the website

NEWS

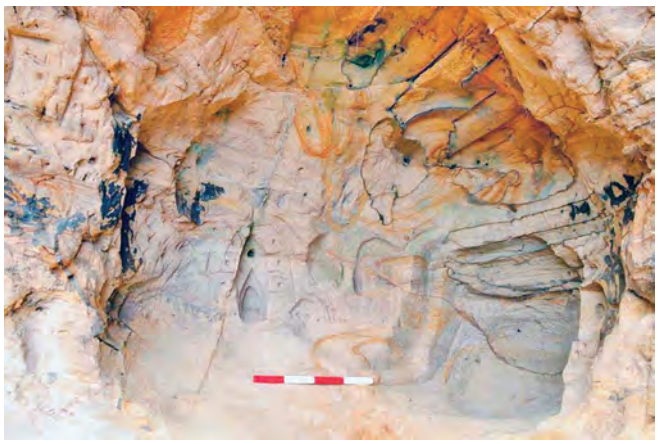
Miscellany compiled by Nick Catford

NEWS – ARCHAEOLOGY

Shrine stops rail workers in their tracks

Railway workers repairing a landslip in Surrey have found a cave that may have been a medieval shrine. Archaeologists believe that the site near Guildford may be linked to the Chapel of St Catherine, the ruins of which are on a nearby hill.

The cave has several sections between 30cm and 70cm high but may have been much larger. Inside was evidence of writing and other markings on the ceiling covered in black dust, thought to be soot from lamps, and the remnants of two fire pits were also found. The cave contains what appears to be shrines or decorated niches. The old name for St Catherine's Hill is Drake-hull, the hill for the dragon, so this has obviously been a site of ritual significance long before the construction of the church on the top of the hill in the late 13th century.



Work is underway to analyse soot and charcoal found inside the cave which will hopefully provide more information about how and when it was used. British Rail said that every effort would be made to preserve elements where possible.

SOURCE: *The Times*, 6 April 2020.

Apidima Cave fossils – Earliest homo sapiens outside Africa

A partial skull found in Apidima Cave, southern Greece, is the earliest evidence of the presence of homo sapiens outside of Africa, scientists have reported. The team of researchers dated the skull to about 210,000 years old, which makes the skull about 150,000 years older than the oldest fossil of homo sapiens previously found in Europe and the third-oldest known example of modern humanity.

A second skull found in the same location was estimated to be at least 170,000 years old belonging to Neanderthals, a species widespread in Europe until 40,000 years ago, when homo sapiens took over. The two skulls (named *Apidima* 1 and 2) were found together in the late 1970s in the Apidima Cave which is located in the Peloponnese in southern Greece. Initial attempts to date the skulls were inconclusive in part because the skulls were found wedged high in the cave walls and may have been mixed with mudflow.

Apidima cave

The research team created virtual reconstructions of parts of the skull and used a radiometric dating method – one that analyses the decay of uranium to determine the age.

The challenge scientists now face is to figure out how *Apidima* 1 fits into our ancient history. It points to an early expansion of homo sapiens into Europe from Africa. That wave of humans may have thrived outside Africa because they brought better tools. Greece may be a good place to test this idea.

SOURCE: *International Journal of Science, Nature*, July 2019.

Underground complex discovered next to Jerusalem's second temple

A team of Israeli archaeologists discovered secretive underground rooms near to the Second Jewish Temple, which was destroyed by the Romans in 70AD. There were two Holy Temples of Jerusalem which were key places of worship and built on the Temple Mount, but they were destroyed firstly by the Babylonians and then by the Romans. The rooms' purpose is still a mystery, but experts have dated them back to some 1,400 years ago. They were discovered below the Western Wall plaza in Jerusalem's Old City.

As with much of Jerusalem, there are deep layers of archaeology where new societies built on top of earlier structures. The rooms were carved into the bedrock, and the archaeologists at first were unaware that they had discovered new structures which are all connected via staircases. Barak Monnickendam-Givon, co-director of the excavation for the Israel Antiquities Authority, said: "At first we were very disappointed because we found we hit the bedrock, meaning that the material culture, the human activity here in Jerusalem ended."

The discovery is about 30 metres from the Temple

The rooms were carved into the bedrock; archaeologists were at first unaware they had discovered new structures

Mount, where the Second Jewish Temple stood, but the rooms don't have any firm link to the temple itself. The archaeologists will investigate further to discover the purpose of the underground complex, but the suggestion is it could have been a series of pantries.

Among other things, clay cooking vessels, cores of oil lamps used for light, a stone mug unique to Second Temple Period Jewish sites, and a fragment of a *qalal* – a large stone basin used to hold water, thought to be linked to Jewish practices of ritual purity.

SOURCE: *Daily Express*, 22 May2020.

Cave system in Ecuador allegedly holds "metallic library" of a lost civilization

In 1976, a major expedition entered the Cueva de los Tayos in search of artificial tunnels, lost gold, strange sculptures, and a "metallic library," supposedly left by a lost civilization aided by extraterrestrials. Among the group was the astronaut Neil Armstrong.

For as long as anyone can remember, the indigenous Shuar people of Ecuador have been entering a vast cave system on the jungle-covered eastern foothills of the Andes. They descend, using ladders made of vines, through one of three vertiginous entrances, the largest of which is a 213-ft-deep shaft that leads into a network of tunnels and chambers stretching, as far as we know, for at least 2.85 miles. The largest chamber measures 295 ft by 787 ft.

Corridor inside Cueve de los Tayos

For the Shuar, these caves have long been a centre for spiritual and ceremonial practices, home to powerful spirits as well as tarantulas, scorpions, spiders and rainbow boas. They are also home to nocturnal oilbirds, known locally as *tayos*, hence the name of the cave. The tayos are a favoured food of the Shuar, another reason why they brave the depths of the cave system.

The Cueva de los Tayos is located in the rainforest about 23 miles southeast of the town of Santiago de Mendez in southeastern Ecuador, not far from the border with Peru. It is within the Sindical Center Coangos, and is therefore on Shuar territory. Access to the cave must be arranged with local Shuar authorities.

Expeditions to the cave can be carried out on foot, by boat, or a combination of the two. It is sometimes also possible to go via helicopter from the town of Macas, some 50 miles north of the caves.

SOURCE: *Atlas Obscura*, July 2020.

Archaeological find delays decision on Stonehenge tunnel

An archaeological find has delayed the decision on whether to build a £2.4 billion road tunnel near Stonehenge. Transport Secretary Grant Shapps has pushed back the announcement to November to allow for "further consultation".

The proposed tunnel would remove the sight and sound of traffic from the frequently congested A303 route but campaigners have argued the scheme would damage the World Heritage site.

In June it emerged that a team of archaeologists had discovered a ring of at least 20 large shafts a short distance from Stonehenge. It is thought they form the largest prehistoric monument ever discovered in Britain, and experts believe they may have served as a boundary to a sacred area.

SOURCE: *BBC News Wiltshire*, 16 July 2020.

14,000-year-old poo found in Oregon cave turns out to be human

For archaeologists, ancient bones and stone tools are important lines of evidence, but sometimes the answers to our past can be found in piles of human poo, as an important new analysis shows.

From 2002 to 2010, archaeologists collected dozens of coprolites, or dried-out poop, from Oregon's Paisley

Caves, the oldest of which were dated to 14,000 years ago. A genetic analysis of the coprolites suggested they came from humans, but some researchers questioned this result, citing possible contamination of the samples. The progeny of the poop remained unresolved for years, but new research is providing a fresh look at these stale but incredibly important piles of dung.

Humans first entered into North America around the end of the last Ice Age, sometime between 20,000 and 15,000 years ago. Further confirmation of exactly when and how this migration took place would be a big deal, even if the evidence in question is literally full of crap.

Coprolites, in order to last for so long, require an arid environment. Plenty of dry caves exist in western North America, but Paisley Caves are special in that they're the only ones known to harbour evidence of human activity dating back to the Pleistocene-Holocene transition.

SOURCE: *Gizsmodo*, 16 July 2020.

NEWS – CONSERVATION AND HERITAGE

Shelter and memorial listed to mark VE Day anniversary

A "unique" bunker and civilian war memorial have been listed for the 75th anniversary of the end of World War Two. The shelter, with a tower to watch out for enemy paratroopers, is near an ex-RAF airfield in Hucknall, Nottinghamshire. The memorial – a stone cross – near St Luke's church in Bromley, south London, is in an area heavily bombed in the war.

Historic England said Grade II listing would help "ensure the rich history of these iconic sites is not forgotten." In Nottinghamshire, the bunker, officially known as the Battle Headquarters, has a three-storey brick tower – believed to be the only surviving example – over a shelter connected to the rest of the airfield.

It was built in 1940 at a time of feverish speculation that the Germans could invade at any moment. Standing on high ground, it was intended to give clear views of possible landing areas for enemy parachute troops and allow for co-ordinated counter-attacks.

The memorial at St Luke's was built after WW1 but Bromley suffered many enemy bomb attacks in WWII because of both its position on the outskirts of London and close proximity to the RAF base at Biggin Hill in Kent. The biggest air raid was in 1941 when 198 bombs were dropped in the area, killing 74 civilians and destroying many buildings including Bromley Parish Church.

Two other sites, the Obelisk at Orange Grove in Bath and Felbrigg Hall Gardens in Norfolk, have had their existing listings updated to include new information about their connection with the war.

The Obelisk, though itself much older, came to mark the special relationship between Bath and the occupied Dutch city of Alkmaar, a connection that has continued to this day. Felbrigg Hall's grounds boast two 350m avenues of beech trees planted in the shape of a V, planted after the war by the last private owner to commemorate peace and his brother who had died in 1941 on active service.

Duncan Wilson, chief executive of Historic England, said: "The surviving physical evidence of the Second World War is all around us, but is often unrecognised. From the Battle Headquarters at RAF Hucknall Airfield to the memorial at St Luke's Church in Bromley; from aircraft hangars, former air-raid shelters, barracks and hospitals, to the thousands of homes that sheltered evacuees; we must ensure that the rich history of these iconic sites is not forgotten."

SOURCE: *MailOnline*, 6 May 2020.

Four WWII bunkers found under Bristol primary schools

A number of World War Two shelters have been found under school playgrounds in Bristol, council papers have revealed. Underground air-raid shelters were discovered in the last year at Hillcrest Primary School, Chester Park Infant School, Two Mile Hill School and Air Balloon Primary School. Two of the shelters have been filled due to their "very dangerous condition", the city council's cabinet was told.

Funds of £75,000 have been assigned to make the other two shelters safe. The work forms part of a £2.5m programme of repairs over the next 12 months to primary schools and other Bristol City Council buildings. A report to Cabinet members, who met remotely on Tuesday, said: "Last year we identified four schools with underground air-raid shelters below their playgrounds. It was identified that these were in a poor condition and required to be in-filled. Two of the structures were in very dangerous condition and were dealt with last year."

The 60m shelter at Hillcrest Primary School – which was in a "very dangerous condition" – has already been filled in with concrete

The walls of the shelter at Hillcrest Primary School were covered in graffiti dating back to the 1940s. It has been filled in with concrete as has the bomb shelter at Chester Park Infant School. Work on the other two at Two Mile Hill and Air Balloon Primary still needs to be completed.

SOURCE: *BBC News Bristol*, 1 May 2020.

Discovery of underground Iron Age temples in Northern Ireland

Digging in the ancient capital of Ulster, one of five mythical Irish royal sites, has revealed vast underground structures dating from the Iron Age. The area is closely linked with Irish myths like the story of the Táin Bó Cúailnge and mythological demigod Cú Chulainn.

Digging has taken place at Nevan Fort, Co. Armagh

A proper excavation will need considerable financing which has not yet become available. However it is hoped that the nearby visitor centre, due to reopen on 30 July after closure due to the coronavirus pandemic, will be able to recruit some enthusiastic amateur archaeologists to get a project underway.

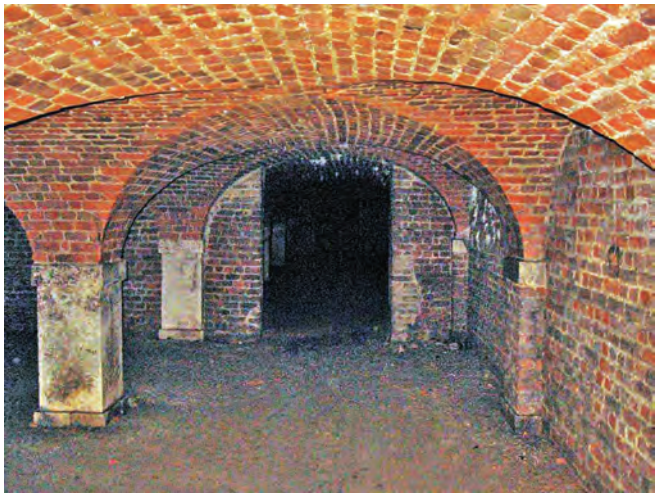
SOURCE: SFES newsletter: https://news-24.fr/, translation 31 July 2020.

Cranford House cellars to be opened to the public

A series of huge vaulted cellars under a demolished mansion house just to the north of Heathrow Airport are to be opened up to the public as part of plans to improve the parklands around them. Cranford House was the summer estate of the Berkeley family for 300 years up to 1918, and although relatively grand, it was for the family, something they considered a hunting lodge - and one of the precursors of the modern Berkeley Hunt now held in Gloucestershire.

The Cranford estate dates back to before the Norman Conquest, and the lands passed through many hands over the centuries, before finally being sold to Elizabeth, widow of Sir Thomas Berkeley in 1618, who may have already owned some land locally. Although the estate remained in the Berkeley family for the next 300 years, the family itself fractured and split a number of times, and the lands eventually ended up with Charles Berkeley, 3rd Baron FitzHardinge, who died childless in 1916. The house was used only intermittently by the Berkeley family from the late 19th century until the First World War. Over the next couple of decades, most of the estates were sold, and Cranford House estate was sold to the local authority in 1932.

The house, having been rarely used for the past 50 years seems to have been in a poor condition, and the council declined to fund the estimated £6,000 restoration costs and convert it into a museum. A tender to demolish the mansion house was issued by Hounslow Council in 1938, but it seems that it wasn't demolished until 1944, and the rest of the estate became Cranford Park and opened up to the public.



Although the mansion house was demolished, the 18th-century stables were retained. The demolition was also to the ground only, leaving the cellars untouched. The cellars appear to date largely from the 1720's, when the 3rd Earl rebuilt the house. JP Black, the architect 1943, believed the central section

to be early 18th with the sections at either end, later additions. The "extensive range of cellars" were described in the *Uxbridge & West Drayton Gazette* newspaper in Feb 1936 as being "vaulted in brickwork supported on square pillars," and contained the "usual traditions of underground passages leading under the park". The cellars are now listed by Historic England, but were also put on the "at risk" register in 2010. Now, at last, they are to be restored and for the first time ever, opened to the public.

An attempt to arrange a special visit for members of Subterranea Britannica was refused in 2018.

SOURCE: Ian Visits blog, 5 August 2020.

NEWS – HEALTH & SAFETY

Four found dead in Greek cave

Four men were found dead by men of the Special Disaster Management Unit (EMAK) inside a cave in the Loutraki area of the Peloponnese in May. Authorities were notified when the wife of one of them reported her husband missing after going to the cave in the Karbounari area, near Loutraki.

The rescue unit found a power generator and an explosive mechanism inside the cave, speculating that the four victims died from asphyxiation from the fumes of the machine. The bodies were carried to the Corinth Hospital for the cause of death to be identified. It is thought that the men were probably hunting for treasure that locals believe is hidden in the cave.

SOURCE: *GreekReporter.com*, 16 May 2020.

NEWS – MILITARY AND DEFENCE

WW1 tunnel system found in Flanders, Belgium

Archaeologists have uncovered a huge World War One tunnel system where dozens of soldiers' remains are believed to be entombed. The underground bunker is located on a hill in Flanders in Belgium where the notorious Battle of Messines – when an estimated 59,562 soldiers were killed – took place in 1917.

During the battle the British pummelled the German fortifications on the ridge with millions of shells. The bunker, which would have accommodated up to 300 troops, was discovered about 20ft below ground, a depth that would have made it shell-proof. But it is thought the artillery bombardment caused the timber-lined walls and ceilings around the entrances to collapse, burying alive the men inside.

Archaeologists have so far uncovered four different entrances, each leading to a flight of 21 wooden steps. But the openings remain blocked by tonnes of earth from the war. Experts believe there are up to four more entrances to the network, which covers an area under a 400-metre section on the main road through the village of Wijtschate. It is hoped that one of these will be accessible to allow them to safely enter the dugout or send in a remote camera.

Part of a flight of 21 wooden steps leading down to the tunnels

Historians have so far uncovered an array of 200 military and personal artefacts, that date back over 100 years. These include a perfectly preserved wooden stretcher, parts of a narrow-gauge railway and a wooden cartwheel. German army helmets have also been found along with a bayonet, a pair of wire cutters and glass bottles.

The Germans occupied the ridge near the city of Ypres from 1914 until June 1917. It was taken by British and Irish troops during the Battle of Messines, which lasted for seven days and effectively saw the Germans battered into submission. The Germans suffered 35,000 casualties, with 1,300 men of the 33 Fusiliers Regiment missing by the end of it – some who may be buried in the underground shelter. Most of the men were taken prisoner but many of them were never found and they still rest there. There could be a real time capsule in the tunnel.

The tunnel network was discovered by Belgian workmen installing a new sewage system in Wijtschate. After they began finding artefacts in the sub-soil they alerted the relevant authorities. Excavation work is being carried out by the Flemish Heritage Agency with the help of archaeology students from Ghent University. The area of Wijtschate was captured and held several times by both sides during the course of the war. After the Battle of Messines, the Germans retook the ridge in 1918.

SOURCE: *MailOnline*, 2 July 2020.

Mortar shell found in air-raid shelter in Leicestershire

A man said he and his family "could have been vaporised" after discovering a rusty "bottle" pulled from a garden shelter was a live WWII bomb.

Peter Cawdell, who lives in Quorn, Leicestershire, had been clearing out the mysterious concrete structure with his daughter when they found the relic. Bomb disposal teams were called to Forest Road in mid-May. Mr Cawdell said at first they were "excited" but on Tuesday "it dawned on us how dangerous it could have been."

Peter Cawdell and his daughter had been taking out about 20 buckets of soil per day to clear the shelter. At first he thought it was an oxygen bottle, but when the soil came off, they weren't so sure. The police were called and after X-raying the item, the bomb disposal team confirmed it as a 4.2in mortar round – the largest used by the British in World War Two – and still live.

Photo Ed Cawdell

Mr Cawdell is keen to continue clearing the shelter as it appears far bigger than a normal domestic air-raid shelter. He said, "It might be a Home Guard command post or something to do with the railway or even the 82nd Airborne Division, who were stationed nearby."

SOURCE: *BBC News*, Leicester, 14 May 2020.

North Korea constructing giant underground missile storage area

North Korea is nearing completion on a giant new facility that could be used to assemble, store and test its most powerful nuclear missiles. The base, under construction near the capital city of Pyongyang, features a rail line connecting to nearby missile factories, three construction hangars and a large underground storage area.

Satellite images suggest the facility will be finished either late this year or in early 2021, when it could be used by Kim Jong Un to protect and bolster the country's stockpile of nuclear weapons. The base will be heavily guarded by 17 air defence bases, multiple ground bases, and nearby anti-aircraft batteries.

Researchers from the Center for Strategic and International Studies in the US said construction on the base began around 2016, when North Korea was developing nuclear missiles capable of hitting the US. Construction workers are believed to have repurposed an underground hangar built in the 1980s to house fighter jets but since abandoned, and built the new base around it.

At its heart sit three large hangars with roads running through them and which are connected by tunnels. One of the hangars includes a large raised centre section, which researchers say is tall enough to house a Hwasong-14 or Hwasong-15 nuclear missile while positioned upright on top of a launcher. The entrances to all the hangars and the interconnecting roads are also large enough for the missiles and their launchers to fit through.

SOURCE: *MailOnline*,7 May 2020**.**

Dog walker finds tunnel network in Plymouth

A dog walker in Plymouth says he was walking his dog along West Hoe when he discovered a hole in the ground. On a closer look, he found "bunker tunnels" beneath the ground – and decided to walk part-way through them.

While the man isn't entirely sure what the tunnels are for, he believes they could have once been linked to the military buildings nearby, or have provided a bomb shelter for locals during the Second World War. Plymouth City Council confirmed it had taken steps to protect the public from any harm. A council team was sent to investigate and ensure the opening is now secure.

It comes months after another dog walker discovered another section of tunnel close to the Hoe waterfront. On this occasion a man was walking his dog on the beach in front of the Wet Wok restaurant one evening when he noticed the storm had washed away the concrete wall to reveal a "cave". Looking inside, he said it appeared big enough to be able to stand up in.

SOURCE: *Plymouth News*, 18 June 2020**.**

Iran claims to have launched ballistic missiles from underground silos

Iran's Revolutionary Guards claim to have launched ballistic missiles from "the depths of the Earth" on 28 July during the last day of military exercises near sensitive Gulf waters. The launches come a day after the Guards struck a mock-up of a US aircraft carrier with volleys of missiles near the Strait of Hormuz, a vital shipping lane for a fifth of world oil output.

Missile launch during an exercise in Iran

State television broadcast aerial footage of the latest daylight exercises in the desert showing bursts of flames, smoke and then dust before what appeared to be four projectiles climbing into the sky. The Islamic Revolutionary Guard Corps (IRGC) said in a statement on its *Sepahnews* website that it was 'the first time in the world' that such an exercise had been carried out.

Satellite images showed the mock-up aircraft carrier being towed by a tugboat to the Strait from the Iranian port city of Bandar Abbas. The mock-up of a Nimitz-class aircraft carrier came into view with rows of dummy fighter jets on either side of its landing strip.

SOURCE: *Sepahnews* website, 28 July 2020.

NEWS – MISCELLANEOUS

Sinkhole closes busy West Midlands road

A large sinkhole suddenly appeared in the West Midlands causing drivers to swerve to avoid it. People in nearby houses ran into the street in Walsall to stop vehicles plummeting into the crater after a sewer collapsed. Severn Trent Water said the repairs would take at least four weeks.

SOURCE: *The Times*, 23 May 2020.

New £19 billion particle accelerator for CERN

A new particle accelerator four times bigger than the Large Hadron Collider is a step closer after CERN agreed to back the £19 billion project. The Future Circle Collider (FCC) will have a 62-mile circumference and be six times more powerful than the Large Hadron Collider (LHC).

The next-generation particle-smashing machine will allow scientists to study the Higgs boson in more detail, as well as provide new insight into dark matter. It has been given unanimous approval by the CERN council. The Future Circle Collider will intersect with the Large Hadron Collider, expanding further out under Switzerland and France in tunnels stretching 62 miles.

Before any work can begin, a geological survey is needed under Geneva and the proposed route of the tunnel – just in case there are underground rivers that would put a stop to the proposals or require a whole new route. The massive project doesn't have universal approval from the scientific community, with some claiming it is a 'waste of money' that would be better spent elsewhere.

Artists impression of the FCC accelerator and tunnel

Approval from CERN doesn't mean it will definitely be going ahead; it will still need to secure funding from EU member states, the UK and other agencies. It also won't be operational until the 2040s, as work won't start on it for about a decade, and it will take just as long to complete the construction of the underground tunnels.

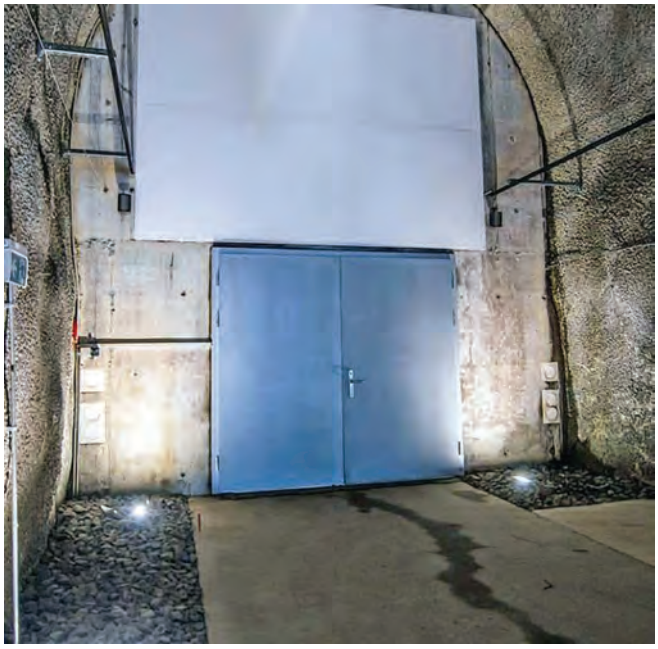
Officials hope for a decision by CERN's 22 member states within the next few years about the project, that would debut with an electron-positron collider at an estimated cost of £8.16 billion. A second phase would involve a superconducting proton machine in the same tunnel – bringing the total cost to about £19 billion. While the first machine would start operations in the 2040s, the second machine could start smashing particles sometime in the late 2050s.

SOURCE: *MailOnline*, 19 June 2020.

Swiss firm will offer mountain vaults to store prized possessions

Switzerland has long been known as the place to go for millionaires to put their money in a safe place. But one firm has taken things to the next level by offering wealthy clients the chance to store their prized possessions in 'treasure chamber' vaults carved into the Alps.

At a starting cost of $500,000, millionaires will feel safe in the knowledge that their assets are being stored within the Bruenig massif, a hulking mountain near Lucerne, central Switzerland. The vaults will range from 3,531 cubic feet to up to 1,000 times that size, according to Bruenig Mega Safe AG, the firm behind the project.



Entrance into the mountain Bruenig Mega Safe AG

The firm claims the vaults will be a "secure place for safekeeping your assets and sensitive data." The vaults will have a height of up to 300 feet and could store things such as art, gold, stock certificates or even classic cars. The thick rock walls of the vaults will allegedly ensure a constant relative humidity of 40 percent and temperature of 53º F.

The project is moving forward in conjunction with Gasser Felstechnik AG, a firm which specialises in underground construction and rock engineering. The vaults will be built alongside several existing businesses located in the mountain; these include a gastropub and explosives depot. Bruenig Mega Safe claim they are in talks with around a dozen potential clients. They include art galleries and wealthy individuals.

Work is set to start next year and the first vaults should be open to wealthy clients around 18 months later.

SOURCE: *MailOnline,* 10 July 2020.

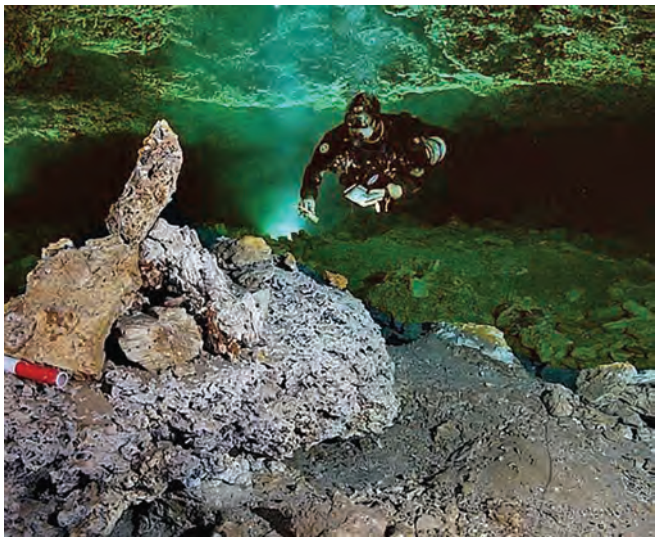
NEWS – MINES AND MINING

Underwater cave in Mexico reveals evidence of 13,000 year-old Mayan mines

Archaeologists in Mexico have found some of the oldest mines in the Americas and 13,000-year-old human remains, after exploring an underwater area in the Yucatan peninsula.

In a paper published in the journal *Science Advances* in early July, the scientists told of finding ochre mines in underwater caves. They had been intrigued by the 2007 discovery in the caves of a young woman they named Naia, who died 13,000 years ago, and wanted to know more about the circumstances of her death. Eight other sets of skeletal remains added to the mystery, with archaeologists wondering how they wound up in the then-dry caves.

The caves, near the resort of Tulum, were flooded about 8,000 years ago due to rising sea levels. The recent discovery of about 900 metres of ochre mines includes the remains of human-set fires, stacked mining debris, simple stone tools, navigational aids and digging sites. The evidence suggested humans went into the caves around 10,000 to 13,000 years ago, seeking iron-rich red ochre, which early peoples in the Americas prized for decoration and rituals.



Such pigments were used in cave paintings, rock art, burials and other structures among early peoples around the globe. The early miners apparently brought torches or firewood to light their work, and broke off pieces of stalagmites to pound out the ochre. They left smoke marks on the roof of the caves that are still visible today.

The early miners may have removed tons of ochre, which, when ground to a paste, can be used to colour hair, skin, rocks or hides in varying shades of red.

SOURCE: *MailOnline,* 5 July 2020.

NAMHO Conference 2021

Preparations have started for what will hopefully be a 'normal' NAMHO Conference in 2021. The conference will be hosted by the Shropshire Caving and Mining Club who are looking to use the same venue, a field study centre about five miles west of Shrewsbury, as they did in 2011. This allows the lectures, reasonable accommodation (including camping), catering and bar to all be on one site in a quiet rural location.

The conference theme is to coincide with SCMC's 60th anniversary and to look at projects in the mining community that have developed with the growth of industrial archaeology and mine exploration during that period, along with the hopes of what the future might bring.

The conference will include the usual mix of trade stands, and local interest and rescue groups will have the opportunity to attend as well. Underground visits will be

concentrated in Shropshire and the Welsh Borderlands, but with the possibility of a few visits further afield either side of the main conference. These will vary from dry, walk-in to multi-pitch SRT. Some water may be present.

Snailbeach adit. There will be surface and underground visits to Snailbeach mine

For those wanting to stay above ground, in addition to the lectures, there will be guided surface visits e.g. Ironbridge Gorge, and route guides for self-led walks around the West Shropshire mine sites.

Obviously, the current situation in the UK makes all of this impossible at present, but SCMC like to be optimistic and hope that by next summer a reasonable degree of normality will have returned. Should this not be the case, then they plan to proceed if a sensible approach can be achieved with the appropriate social distancing measures required. If these prove too impractical for a 'live' Conference, then we will aim to provide an online event of lectures, film presentations, photo competitions etc.

SOURCE: Shropshire Cave and Mining Club newsletter.

Tremors strike the world's biggest underground iron ore mine in Sweden

Sweden has recorded one of its largest ever earthquakes after a 4.1-magnitude tremor hit the world's biggest underground iron ore mine on 18 May.

Miners at work in the 1950s

The quake north of the Arctic Circle was just short of Sweden's record 4.3-magnitude tremor, which hit the south of the country in December 2008. Thirteen people were in the mine at the time, but none were injured and the facility has since been closed. The mine, which is more than a century old, produced more than 14 tons of iron ore products in 2019. The facility, run by state firm LKAB, is known as the Kiruna mine after the city where it is based. The water level in the Kiruna mine was rising but pumps were working.

The Norwegian Seismic Array NORSAR said the earthquake was tied to the ore extraction activities. Swedish officials plan to move the city centre of Kiruna two miles to the east for safety reasons under a plan drawn up in 2004.

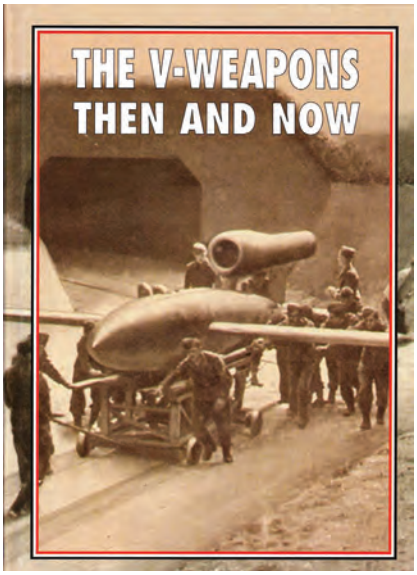
SOURCE: *MailOnline*, 18 May 2020.

NEWS – PUBLICATIONS

The V-Weapons Then and Now

RAMSEY Winston (Ed), 2020, Battle of Britain International Ltd, 288pp. [ISBN 978-1-8700-6799-7] £37.50

Book review by Martin Dixon



"London and southern England has for weeks now been the target of our V1, which is only the first link in a chain of new and strongest German weapons." So wrote the editor of *Der Adler (The Eagle)*, the house magazine of the Luftwaffe, in August 1944.

Many Sub Brit members will be familiar with the *After the Battle* quarterly magazine which has, in almost 200 editions, addressed a huge number of aspects of World War II. Every so often, a hardback book is published, treating a single subject in great depth, and this recent addition is a cracker. The backbone of the family of publications is a comparison of photographs taken during the war with the same scene today. But there is lots more than that in this volume.

Editor-in-Chief Winston Ramsey has taken the formerly classified RAF narrative of the flying bomb and rocket campaigns and used this to tell the whole story in fascinating detail. The volume starts by describing the key players and the research site at Peenemünde on the Baltic Sea in northern Germany.

This is followed by details of Operation Crossbow – the Allied bombing attacks on the manufacturing, storage

and launch sites for the so-called *Vergeltungswaffen* (Revenge, or Vengeance) weapons. Many of the sites are illustrated with aerial reconnaissance photographs of the targets, showing a density of bomb craters that indicates the ferocity of the bombing campaign.

Many Crossbow targets were underground – hence the particular interest of the weapons programme to members. These sites include many visited on Sub Brit trips to France and Germany including Éperlecques, Nordhausen, Siracourt and Wizernes (*La Coupole*); the V3 'pump gun' installation at Mimoyecques is also described.

Each of the numerous V1 launch sites had its own small fire-control (*Feuerstellung*) bunker. For many sites, the Allies monitored construction and only initiated bombing when a site was almost complete, thus maximising the wasted effort of manpower and materials by the Germans.

Later chapters describe in great detail the whole of the attacks on Britain by the V-weapons. These started a week after D-Day and continued until the end of March 1945. The location, date and time of all weapons that detonated in the UK is tabulated, with many photos showing the impact site today – often placed alongside wartime photos.

Many of the latter show the original censorship imposed to conceal the exact locations and the extent of the damage caused. Once launch sites in France were overrun, over one thousand V1s were air-launched from beneath Heinkel bombers.

Defences against the incoming V1s are well covered. These included fighter patrols over the English Channel, a coastal anti-aircraft belt, and barrage balloon installations to the southeast of London. Many anti-aircraft guns were relocated to the south coast and remarkably over 1,500 guns (and their attendant crews and ammunition) were moved over a five-day period in July 1944.

Little could be done to intercept V2s, rockets that arrived at over twice the speed of sound. Many assume that V2s were painted in a distinctive black and white paint scheme but this was only used to help record test flights – photographs show operational rockets had full camouflage for (pre-launch) concealment.

Memorials to some of the many victims of the campaign are also covered. The attacks caused huge numbers of civilian casualties in and around London – the worst V1 attack on 18 June 1944 killed 121 at the Guards Chapel in Birdcage Walk.

This chilling statistic was exceeded by the V2 that killed 168 in New Cross when a Woolworths store was hit in November of the same year. Even these figures are dwarfed by the casualties of the V2 that hit the Rex Cinema in Antwerp (some continental impacts are included) where 569 people lost their lives on 16 December 1944.

The book picks up threads from two recent Sub Brit webinars, including 'then and now' aerial images of the V1 production and storage facility at Saint-Leu-d'Esserent described by John Smiles. The Christmas Eve attack on Manchester by over 50 (air-launched) V1s described by Phil Catling in his talk on Stockport is also covered, with an excellent map showing where all these bombs landed.

Another Sub Brit connection is that some of the book's photos (all well acknowledged) were taken by Nick Catford. One attack landed on the doorstep of the deep-level shelter at Goodge Street, at the time being used by US Forces under General Eisenhower.

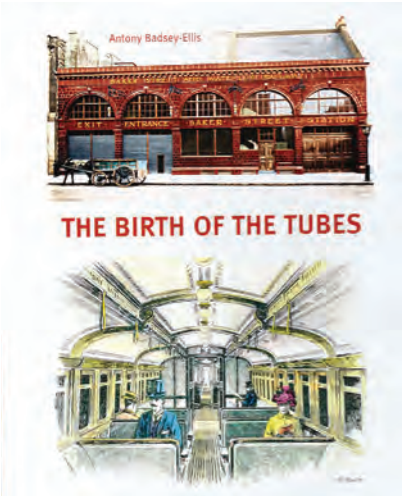
There are few faults to be found. The extensive index appears to be missing a few entries (New Cross for example is absent) and some sites are sub-indexed under London, which can be confusing. A few very minor typos have slipped through but these in no way detract from the enjoyment of the book. The volume represents a sizeable investment but the price reflects its quality.

There are individual books with more detail on specific aspects of the V-weapons campaign (such as Peenemünde or the work of RAF Medmenham Central (Photographic) Interpretation Unit). However, if you want a well-written description of the whole story, supported by over 750 illustrations, then this volume cannot be more warmly recommended.

The Birth of the Tubes

BADSEY-ELLIS Antony, 2019, Capital Transport Publishing, 96pp. [ISBN 9781-85414-441-6] £16.95

Book review by Martin Dixon



You might think that enough books have already been published on the history of London's underground railways; especially with the surge that accompanied the 150th anniversary in 2013. Here, however, we have something a little different. Firstly, it is focused on the true 'Tubes' – the deep-level excavated part of the network. Secondly, the topic is approached through the eyes of literature of the time – newspapers, magazines and promotional material.

Around half of the chapters are devoted to the individual lines – starting in 1890 with the City and South London

Railway (part of today's Northern line). The book's account finishes with the outbreak of World War I so the Charing Cross, Euston and Hampstead Railway (opened in 1907 and also now part of the Northern line) is the last line featured. This makes the 'birth' of the title 24 years long although some planned lines never saw the light of day.

The rest of the book comprises chapters with themes such as power supply, escalators and even the appearance of the Tube in popular board games. Some of these chapters are very short, in some cases just a couple of pages. A bibliography is featured but no index is provided which is a shame. The illustrations are the strong part of the book, featuring as they do the reception the network received as the components were being pieced together.

A number of photos and postcards are hand coloured (some historic and some modern-day) which helps lift the illustrations from a monochrome monotony. I would have preferred the fine drawings of rolling stock to have been coloured too to highlight the liveries of the different lines.

I would also have liked some of the images to have been reproduced at a larger scale – the text on some is a little difficult to read and I think that postcards in particular should not have been reduced in size. There is an irritating inconsistency in the attribution of newspaper articles – in some cases both the name of the publication and date are quoted, in others just one of the two, and some articles are completely unattributed.

The extent to which the Tube network was (literally and metaphorically) ground-breaking is made clear. The City and South London Railway was originally planned to be cable-hauled, as the Tower Subway before it was, but the brave decision was taken to use electric propulsion despite the fact that the technology was very much in its infancy.

The novelty of escalators was such that an advert to travel by Tube to the 1914 FA Cup semi-final between Aston Villa and Liverpool had the text THE LARGEST MOVING STAIRWAYS IN THE WORLD (at Paddington) in a larger font size than the location of the match itself (Tottenham Hotspur's ground at White Hart Lane).

Some of the text comes across a bit clumsily, for example the description of Yerkes' platform tiling includes: *...vertical rings two and a half tiles wide projecting over the tunnel vault and down to the trackside to train roof level...* which is a little difficult to fathom. Similarly, the description of gradient-assisted acceleration and braking is described as *...the platforms were aligned at a higher level than the tracks between stations as this helped the trains to slow as they approached.*

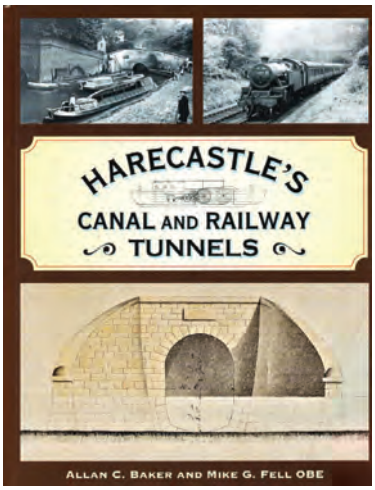
All in all however this is an interesting little publication, containing many articles and illustrations that I have not seen before and which well deserve to be brought out of archives. Its appearance is a little like a scrap book and this is no bad thing. However, it would be all the better by being longer – both by including more material and by increasing the size of some of the images within.

Antony Badsey-Ellis is a prolific author on the capital's underground heritage and if you want to get a flavour of how the Tube was received in its infancy, with a good slab of period advertising and some interesting map treatments, then this is for you. But if you have a more specific interest in particular aspects of construction, design or operation, there are more detailed specialist publications available.

Harecastle's Canal and Railway Tunnels

BAKER Allan C, and FELL, Mike, 2019, Lightmoor Press, 208pp. [ISBN 978-1-911038-62-7] £25

Book review by Martin Dixon



Harecastle, to the north of Stoke on Trent, is unusual in having two parallel canal tunnels, by which the Trent and Mersey Canal passes through Harecastle Hill. Adding yet more underground interest are four railway tunnels. Three of these were sequential on the same double-track line (contrasting with the three parallel railway tunnels at Standedge) and the fourth was built as late as the 1960s when two of the earlier railway tunnels were bypassed and the third one opened up.

Allan Baker and Mike Fell were both originally from North Staffordshire and have spent countless hours researching and documenting these tremendous engineering enterprises. The result is a book of fine detail, supported by comprehensive illustrations. Three of the railway tunnel portals and all four canal tunnel portals are Grade II listed but, following Historic England's usual (bizarre) practice, the actual bores (the most important part!) have no statutory protection at all.

The book is clearly separated into chapters which each address one of the main periods of construction and operation. The thoroughfares which pass through the tunnels – the Trent and Mersey Canal (originally the Grand Trunk Canal) and the North Staffordshire Railway – are separately described and a chapter is devoted to each of the main construction periods.

The first canal tunnel was engineered by Brindley and dates from 1775. At the time of construction, it was the

world's longest canal tunnel at 2,880 yards. Its width however was a maximum of nine feet which made it too narrow for boats to pass each other and as a result of congestion and subsidence a second tunnel was built by Telford in 1827.

The opportunity was also taken to build a wider tunnel which included a towpath. The Telford tunnel alone took almost nine million bricks to construct. For many years the Brindley Tunnel was used for southbound traffic and the Telford one for northbound.

Subsidence remained an issue and a chapter is devoted to a possible diversion to completely avoid the tunnels which was investigated in 1911. This was costed at £57m in current-day prices; given the growth of the railways it is little surprise that it was not proceeded with.

The canal story is followed by the construction details of the three railway tunnels of 1848 and most recently the 1966 'diversion' tunnel for the railway which did go ahead. The diversion line was built partially to counteract movements in the strata surrounding the original trio of rail tunnels, but more specifically to allow room for the overhead lines for the London Midland Region's mainline electrification scheme.

A chapter is also devoted to the operation through the Telford canal tunnel of electric tugs which operated between 1914 and 1954. The tug pulled itself through the tunnel on a fixed iron rope using five-feet diameter winding drums, the electricity coming from battery banks in 'accumulator barges'. Later (from 1931) the tug drew its power from an overhead conductor instead.

Harecastle Canal Tunnel Portals. The northern portals of the two Harecastle canal tunnels. On the right is the Brindley tunnel, disused since 1914. On the left is the still active Telford tunnel; you can see how close the parallel tunnels are to each other. Boat traffic is only admitted under the control of the lock keepers who sequence convoys of up to eight boats alternating in direction. Photo Martin Dixon

The final chapter is of particular interest to Sub Brit members as it describes the extensive coal and ironstone mining that took place inside Harecastle Hill, some of the output being directly loaded onto boats in side tunnels off the main Trent and Mersey Canal. During the Festival of Britain in 1951 the disused coal workings could be visited for a shilling.

The supporting photographs, plans, correspondence and tables are particularly fine and mean that the work is standalone without the need for most readers to refer to the bibliographical sources. Photos cover both construction and operation of the tunnels and both feature people at work as well as images of the engineering involved.

Most of the tunnel photographs understandably focus on the portals and approaches of the various tunnels but an interesting appendix includes a photographic voyage through Brindley's tunnel taken from a 1979 inspection.

There is perhaps an opportunity missed in not having a few 'then and now' side-by-side photographic comparisons showing how scenes have changed since early days. The present day is also touched on only very lightly in the text and there is scope for including more detail on current-day leisure boat usage and conditions for transiting the Telford tunnel.

A summary or conclusion at the end of the book would have helped tie things together; as it is, it seems to end rather abruptly. These are small criticisms however of what is an important, well researched, well written and recommended volume.

NEWS – TUNNELS AND TUNNELLING

Millionaire has tunnel vision, West Sussex

A millionaire's plan to dig a tunnel between the two halves of his garden has received a boost from the Planning Inspectorate, which says it is unlikely to significantly harm the environment. George Chapman, a retired company director, wants to tunnel under the public footpath that divides his garden in West Wittering, West Sussex.

Mr Chapman's neighbours, Simon Hill-Norton, founder of fitness clothing brand *Sweaty Betty*, and Oliver Tress, who set up home and fashion store *Oliver Bonas*, objected. Chichester District Council went against its officials and rejected the plan, and Mr Chapman is now appealing to the Inspectorate.

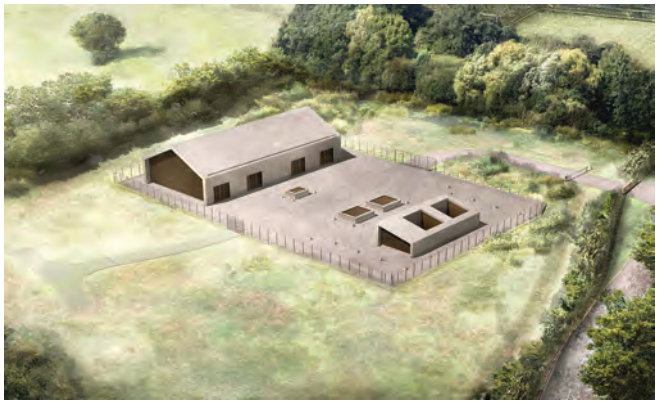
SOURCE: *Daily Telegraph*, 25 June 2020.

HS2 reveals final design for Chiltern tunnel vent shafthead

HS2 has revealed the final design for the Chalfont St Peter vent shaft headhouse – the first of four similar structures that will provide ventilation and emergency access to the high-speed rail line's ten-mile-long Chiltern tunnel. Set back from the road, the single-storey building will be wrapped in a simple grey zinc roof with doors and vent openings picked out in a dark bronze colour to provide contrast.

Taking its inspiration from the style of local barns and other agricultural buildings, the headhouse is designed to fit into the surrounding landscape. The pre-weathered

grey zinc roof will age naturally over time, without loss of robustness or quality, while the whole structure will sit on a simple dark blue brick base.



Artist's impression of the Chalfont St Peter vent shaft and headhouse

Below ground level, a 60-metre ventilation shaft will reach down to the twin tunnels below, with fans and other equipment designed to regulate air quality and temperature in the tunnels, remove smoke in the event of a fire and provide access for the emergency services.

Mature trees along the existing boundary are being retained as far as possible and once construction is complete the whole site will be landscaped with new trees and hedgerows planted to help screen the site from neighbouring properties. The overall scale and visual impact of the building has also been significantly reduced.

To encourage wildlife to return, bird boxes, reptile basking banks, a grass snake laying heap and a hibernaculum will also be created. Material excavated from the shaft will be used to create much of the landscaping and avoid putting extra lorries onto local roads.

SOURCE: HS2 Press Release, 23 July 2020.

Elon Musk tweets first renders of his Las Vegas loop station

Elon Musk released the first ever renders of the Boring Company's Las Vegas loop station, where passengers will carted away by high-speed autonomous Teslas.

First render of the station where passengers will board Tesla's driverless cars to travel across the Las Vegas Convention Center at high speeds

The render depicts a hub for future passengers of the Boring Company's underground loop which aims to zip people from one end of the Las Vegas Convention Center to the other. It shows what appears to be a fairly modern, bright design with a centred escalator leading down to a floor staggered with Tesla's driverless vehicles. The image shows Tesla's Model 3 electric vehicles which are one of those the company plans to use for carting passengers between locations.

Above the tunnels is a display showing passengers when and where their vehicles will depart and, for colour, a sprawling wall ad for Las Vegas tourism sporting the city's *What happens in Vegas, only happens here* slogan. The cars will use onboard self-driving software to navigate the tunnels in addition to 'tracking wheels' which guide the vehicle along its specific lane. Musk has said that the vehicles will reach top speeds of 150 miles per hour, making the journey more of a sprint than your typical shuttle ride.

The renders are, of course, only tentative at this point and could change drastically between now and when the station is actually built. They do, however, show the progression of Musk's Las Vegas loop, which he claims is "coming soon."

Excavation work on the second of the two-tunnel system began on 13 March beneath the Las Vegas Convention Center.

In May, the company completed its excavation of one of two tunnels making up the convention centre loop. The boring machine today broke through the concrete wall near the 1.4 million sq ft West Hall convention centre expansion, which is currently 80 percent complete, signalling the completion of excavation for the two one-way tunnels known as the Convention Center Loop.

SOURCE: *MailOnline*, 22 July 2020.

Victorian tunnel uncovered in the Lake District after 50 years

A hidden tunnel has re-emerged in the Lake District as part of a multi-million-pound project to create a new path. The 80-metre-long Victorian tunnel near Keswick was filled in after the railway line from Penrith to Keswick was closed in the early 1970s.

The arched underground passage was built in 1872 and was originally part of a mineral line bringing coal between west Cumbria and Durham. A walking trail was created after that, which runs along the disused tracks, but it suffered extensive damage during Storm Desmond in 2015. The path is now being upgraded at a cost of £8

million to repair two of the old railway bridges that cross the River Greta and replace around 200 metres of the trail that were washed away.

The tunnel is near Keswick on the Penrith – Keswick line which closed 6 March 1972

After weeks of hard work, thousands of tons of debris have been dug out of the tunnel uncovering original brickwork and features that are in a remarkable condition. It's not known why the tunnel was completely filled in.

Workers are now lowering the ground level by several metres as it will be an accessible route for cyclists, walkers and wheelchair-users largely made from tarmac. If the good weather holds, the path is on course to open in December and the tunnel will be back in action nearly 150 years after it was built.

SOURCE: *ITV News,* 9 June 2020.

Old railway tunnel illuminated by glow worms in Australia

Flooded railway tracks lead to an abandoned tunnel nearly lost within a cascade of leafy greenery. Once inside, an enchanting blue glow illuminates the dark, dank tunnel.

Officially called the Metropolitan Tunnel, it was built in the 1880s for the old Sutherland to Wollongong line. Its use was short-lived, as it closed in 1915 after years of soot and smoke built up within the space and made it dangerous for the trains' crews and passengers to pass through.

One end of the tunnel was sealed so it could be used as a reservoir. The north entrance, however, became blocked from years of mucky debris building up outside. The whole tunnel was nearly hidden behind a thick veil of lush flora. Before it was drained and partially cleared in 1995, the entire passageway was full of stagnant water.

But the tunnel wasn't completely abandoned during this time. A colony of glow worms – one of the largest in all of New South Wales – moved in and made its home under the roof. The insects illuminate the stale, inky air like a constellation of blue-green stars.

The tunnel still floods quite frequently. On days when the water level is particularly high, people pass through the small waterfall that often tumbles across the entrance after heavy rains with pool floats or inflatable canoes in hand. They then paddle deep into the darkness until they reach the spots where the ceiling becomes brightest with the soft glow of the bioluminescent bugs.

SOURCE: *Atlas Obscura,* May 2020.

Covid delays Crossrail opening, London

The heavily delayed Crossrail will not open as planned in summer 2021 because of delays caused by coronavirus. The troubled railway, from Berkshire to Essex via central London, was originally expected to open in December 2018 but repeated delays have pushed it back.

A spokesman recently stated: "A programme of this scale and complexity was already challenging – the impact of Covid-19 has clearly made the existing pressures more acute. Due to a pause of physical activity on sites and significant constraints on ongoing work, time has been lost, only some of which can be recovered. The opening of the central section between Paddington and Abbey Wood next summer, as announced earlier this year prior to Covid-19, is not achievable."

Crossrail did not provide a new date for when the railway line, to be called the Elizabeth line, was now expected to be open, stating that a "more comprehensive update" would be issued in due course.

Despite the challenges presented by Covid-19, good progress continues to be made with completing the remaining construction works, with much of this work coming to an end along with software testing for the signalling and train systems. The focus is on completing the outstanding works across the tunnels, shafts and portals so that intensive operational testing can begin and the Elizabeth line can be delivered at the earliest opportunity.

SOURCE: *The Guardian,* 23 July 2020.

Tunnel linking Bluewater to Ebbsfleet Garden City approved

A £12million tunnel linking Bluewater to Ebbsfleet Garden City has been given the green light despite concerns over safety for cyclists and walkers.

Kent County Council's planning committee approved plans drawn up by Maidstone County Hall chiefs to connect more than 6,000 homes at Eastern Quarry, known as Whitecliffe, to Dartford's landmark shopping centre. The planned housing development is bordered by Bean Road and Bluewater on one side and Ebbsfleet International on the other.

Artists impression of the Ebbsfleet Garden City tunnel

The 80m tunnel used by the Fastrack bus service is expected to be in operation from April 2022. Buses will use the site every five minutes, travelling at slow speeds of 20mph. Emergency vehicles will be allowed access, however cars will not. There will also be a 2m wide footway on the southern side of the tunnel and a 3m wide shared cycle and pedestrian pavement on the other side.

SOURCE: *KentOnline*, 27 May 2020.

Tunnel could replace pylons at Dwyryd Estuary

A bid to remove overhead pylons from a Gwynedd beauty spot has been formally submitted to council planners. The National Grid wants to remove ten of the pylons and replace them with a 3km tunnel under the Dwyryd Estuary in order to reduce the visual impact on the site which sits partially within the Snowdonia National Park.

According to the Grid, the project aims to enhance the landscape from Garth on the edge of Penrhyndeudraeth to Cilfor on the opposite side of the Dwyryd Estuary. The scheme forms part of the Grid's £500m Visual Impact Provision (VIP) programme to remove overhead pylons in areas of outstanding natural beauty.

If approved, two new tunnel head houses will give access to the tunnel, and a sealing end compound at the eastern end will connect the cables back to the overhead line. Work on the project would commence on site in 2021 with construction complete and the pylons removed in 2026.

The section of overhead line, constructed in 1966, is part of the 400kV electricity route connecting the Pentir substation near Bangor with the former Trawsfynydd Power Station, now a 400kV substation.

SOURCE: *North Wales Chronicle*, 29 March 2020.

Historic narrowboat makes emergency inspection of Blisworth tunnel

A historic narrowboat was commandeered at short notice by the Canal and River Trust when a workboat was needed to inspect the safety of Blisworth Tunnel on the central Grand Union Canal.

The inspection was called for after a sinkhole was found in the ground above the tunnel's central section, restored in the 1980s. Fearing possible damage to the modern concrete bore, CRT engineers needed a boat quickly and couldn't summon one of their own in time.

The 1935 GUCC motor narrowboat *Sculptor* was handily moored just along the towpath at the canal museum at Stoke Bruerne and seemed ideal for a quick response. Being part of the museum collection and on the Register of National Historic Ships, special permission was sought to use it.

Canal and River Trust engineers inspect Blisworth Tunnel aboard Sculptor

The inspection found a small amount of displacement in the tunnel lining but CRT said there was nothing to cause immediate concern or require a closure. Further investigations will take place once the coronavirus restrictions ease but the inspection allowed the trust to ensure the tunnel is safe.

After its commercial carrying days, *Sculptor* was a British Waterways maintenance boat until 1985 when it became a floating exhibit. It is maintained in full working condition and regularly attends the Braunston Historic Boat Show in June.

Ironically the emergency deployment, its first official work in 35 years, came the same week as it was announced that this year's Braunston Show is cancelled due to coronavirus. The cancellation will be keenly felt; each year since 2007 the Braunston Marina has given £1000 from the show's proceeds towards *Sculptor*'s maintenance.

SOURCE: *Waterways World*, June 2020.

Giant tunnel boring machine arrives in London

Another giant tunnel boring machine has made its arrival in London as workers complete the last stretch of the capital's £4.2billion 'super sewer' project beneath the Thames. The large cylindrical device, named *Selina*, which is set to create the final 5.5km stretch of the 15-mile Thames Tideway Tunnel scheme, was delivered to Chambers Wharf in Bermondsey in early July.

Estimated to cost nearly half the amount of the 2012 Olympics, work for the new sewage system began in 2016 and is the biggest infrastructure project ever undertaken by the UK water industry.

Tideaway, the company behind delivering the Thames Tideway Tunnel in London, has confirmed that the machine will be lifted onto the site before beginning her underground journey toward Abbey Mills Pumping Station later in the year. The project will stretch all the way from Acton in west London, along the general path of the River Thames, towards Limehouse where it will veer northeast to Abbey Mills Pumping Station near Stratford.

Selina is one of six tunnel boring machines being used to create the super sewage project which will be situated 200 feet below the river. The machine is named after Dr Selina Fox, who founded the Bermondsey Medical Mission in 1904. The original hospital created by Dr Fox, who was the daughter of a renowned civil engineer, consisted of just eight beds and was able to provide medical care to women and children in the local area.

Thames Water previously insisted the multi-billion pound project was crucial to stop London returning to the days of the 'Great Stink' when the river acted as an open sewer. At the time, in the mid-1850s, residents complained of the smell

from the river which was full of raw sewage. The problem was eventually solved by engineer Sir Joseph Bazalgette, who built a 1,300 mile network of Victorian sewers to stop untreated sewage being pumped into the Thames.

Built from three main construction sites in Fulham, Battersea and Southwark, the Thames Tideway Tunnel is expected to help treat some of the 55 million tonnes of 'overflow' raw sewage which the current system cannot cope with and is expected to be finished in 2024. The new system will intercept the sewage before it enters the river and carefully treat it before pumping it back into the water in East London.

SOURCE: *MailOnline*, 9 July 2020.

Undersea tunnel "would be cheaper" but could hit problems

A bridge linking Scotland and Northern Ireland could become as critical a part of the UK infrastructure as the M25, a Cabinet minister has said. Brandon Lewis, the Northern Ireland Secretary, said yesterday that the so-called "Boris Bridge" would boost connectivity and was a "good thing, not just for Scotland and Northern Ireland but for the whole of our economy."

The estimated £20 billion bridge is envisioned to run from Portpatrick in Dumfries and Galloway to Larne, in County Antrim. However, one obstacle to this route would be that it crosses Beaufort's Dyke, the UK's largest offshore dump for munitions, which range from small arms to high explosives, after the Second World War. The trench measures 31 miles long and 2.2 miles wide and the munitions could prove dangerous if a bridge were to be built over it.

In 2018, *The Daily Telegraph* revealed that the Prime Minister, then as foreign secretary, had backed plans for a £15 billion 24-mile bridge, and had the backing of the DUP. Earlier this week, Mr Johnson's spokesman said: "Government officials have done some work on this and they continue to work on a range of connectivity projects looking into, as the PM said, road, rail air and cross-sea links between all four parts of the United Kingdom."

However, Nicola Sturgeon, First Minister of Scotland, suggested that £20 billion would be better spent on "more important priorities".

Earlier this year, the Government appeared to favour a tunnel running between the two countries. Alister Jack, the Scottish Secretary and MP for Dumfries and Galloway, said a tunnel would be cheaper, and that a bridge could have to close for up to 100 days a year because of high winds. He didn't mention the munitions.

SOURCE: *Daily Telegraph*, 24 July 2020.

LATE NEWS

1,300ft Mexican smuggling tunnel the longest in US history

A tunnel found stretching from Arizona to Mexico appears to be 'the most sophisticated in U.S. history,' authorities said when it was discovered in early August.

The tunnel, which was not yet finished, ran from San Luis, Arizona, underneath the Yuma border, to a Mexican neighbourhood and had a ventilation system, water lines, electrical wiring, a rail system and extensive reinforcement. The tunnel extends 1,300 feet from San Luis Rio Colorado, Mexico, to San Luis, Arizona. Its terminus is located just yards away from a residential neighborhood on the American side of the border, although it's likely the unfinished tunnel was meant to conclude within a residence controlled by smugglers within the United States.

No arrests have yet been made but agents are working closely with Mexican law enforcement to bring those who built it to justice. Homeland Security Investigations found the tunnel in mid-July when they discovered a sinkhole in the area of a tunnel investigation. On 27 July, they began drilling near the sinkhole, under which they found pieces of wood and water hoses. A camera was sent 25 feet underground, which confirmed the existence of the tunnel.

SOURCE: *MailOnline*, 7 August 2020.

Coldwaltham Cut and Hardham Tunnel – Arun Navigation, West Sussex

Nick Catford and Gill Davies

Looking north along Hardham tunnel from the South portal in May 2017.
Distances from the portal are marked on the wall in yellow and measured in yards. Photo Kevin Roach

The town of Arundel in West Sussex has been accessible by boats on the River Arun since at least the Norman Conquest in the 11th century, when Caen stone was imported from France for the castle keep at Arundel.

Improvements to the River Arun were completed by the mid-16th century. They included widening, deepening and rerouting the river channel closer to Arundel to make the town a port for sea-going vessels and extending navigation north to a turning point below Stopham Bridge at the junction of the rivers Arun and Rother.

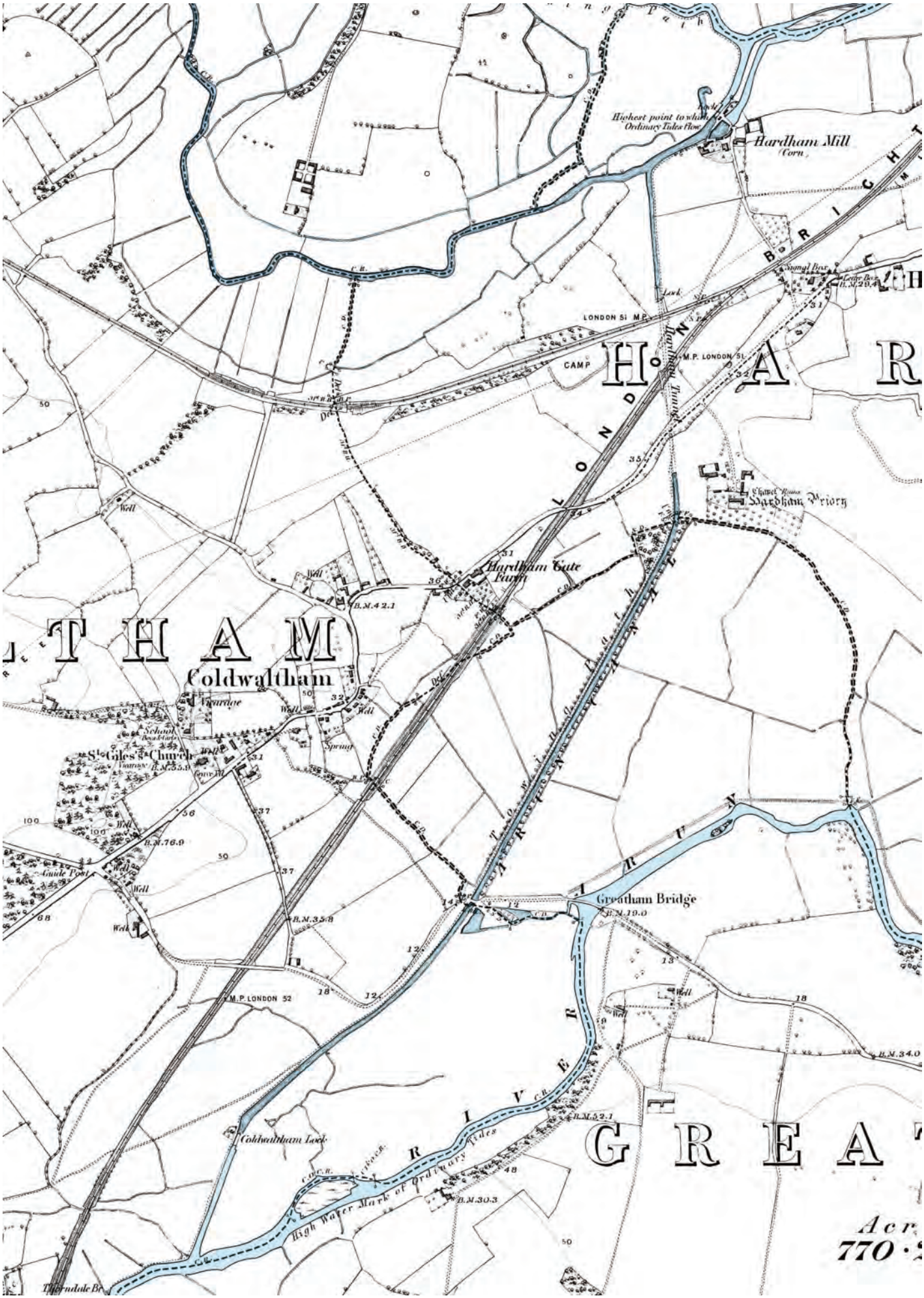
However no attempts to further extend the navigation came until the 18th century with the Arun Navigation Act. *An Act for amending and improving the Navigation of the River Arun, from Houghton Bridge, in the parish of Houghton, in the county of Sussex, to Pallenham Wharf, in the parish of Wisborough Green* received Royal Assent on 13 May 1785.

First Cut is the Deepest

The Act authorised works to improve the Arun upstream from Houghton Bridge (the tidal limit) to Newbridge, near Billingshurst. This involved the construction of two artificial cuts, one of 1¾ miles between Coldwaltham and Hardham including a 375-yard tunnel and three locks (Waltham, aka Coldwaltham, Tunnel and Hardham); and a 4½ mile cut (with three locks at Pallingham, Middle aka Leefarm and Orfold) between Newbridge and Pallingham. The longer cut was completed in 1787 but the Coldwaltham Cut was suspended until a mortgage on the tolls could be raised.

The authorising act made no mention of a tunnel and it seems likely that a deep cutting through Hardham Hill

Arundel port in 1820



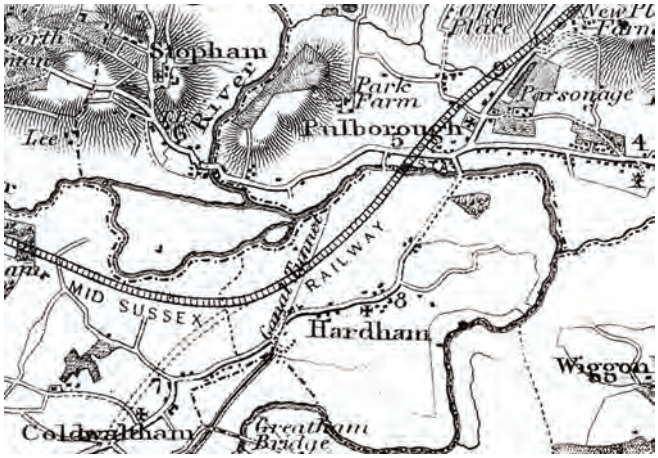
1880 (Surveyed 1876) 1:10,560 (6") OS map showing the Coldwaltham Cut (with three locks, Hardham, Tunnel and Waltham) and the Hardham Tunnel

was originally planned and it was only decided to build a tunnel due to opposition from adjacent landowners. The Coldwaltham Cut and Hardham tunnel were engineered by James Edwards and were eventfully completed in time for the opening of the Lower Arun Navigation on 14 August 1790 with hundreds of onlookers keen to see the departure of the specially decorated barge from Waltham Lock.

Tunnel Lock and the north portal of Hardham Tunnel in 1849. Sketch Thomas Evershed

The *Sussex Weekly Advertiser* recorded the event: "Cold collation and plenty of wine were provided while the workmen emptied two or three hogsheads of strong beer given to them by their masters." A guest further recorded, "The opening and passing through the Tunnel, at Hardham Hill, was a novel, and interesting sight to me. The day was remarkably fine. About one o'clock the first barge gave the signal for starting by a discharge of cannon mounted thereon; the barge was followed by two more, very much crowded with company, both of ladies and gentlemen.

"In the first of these, was a band of music; at the entrance the first barge again fired her guns, and then the procession proceeded through the subterraneous passage; the gloomyness of the scene, and the faint sound of the music, were altogether charming; at coming out of the tunnel, the guns again saluted, the colours were again hoisted, and the barges and company passed through the locks, and so to Stopham.



1861 1" map

Here, booths were pleasantly placed, wherein the company dined; after which contest between some barges took place which included a guinea being awarded to the barge loaded with 30 tons of chalk which passed through the tunnel in the shortest time. Much jollity and humour, mark'd the evening, and the welkin resounded with the cheers of the multitude and the noise of the cannon."

Cut and Cover and Collapse

There is an anomaly in the contemporary account of proceedings which gives the length of the tunnel as about 440yards. The 1876 OS map, reproduced here, shows the length as 375 yards.

South Portal of Hardham Tunnel in 1849. The portal has no parapet.

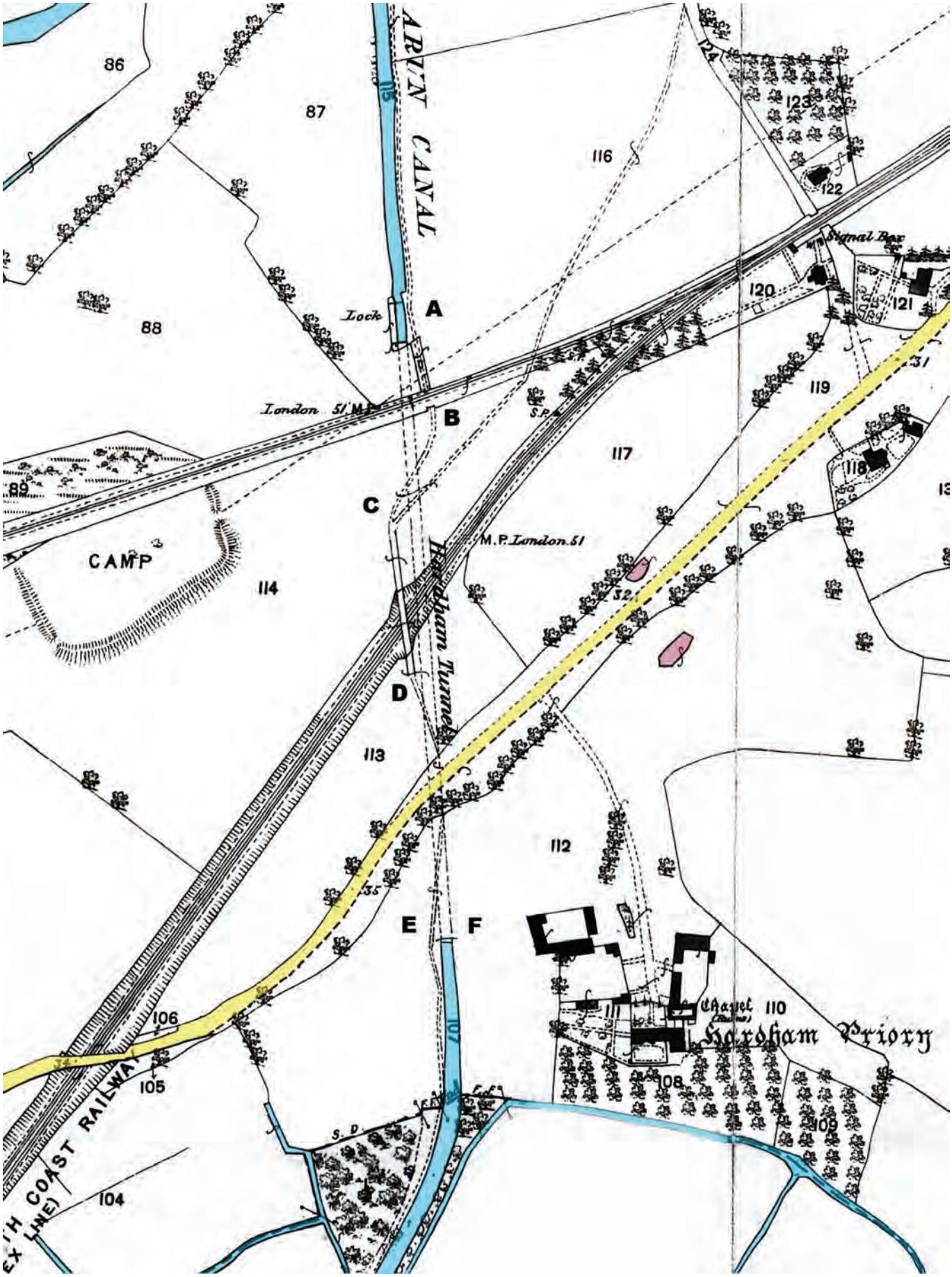
It appears that an early collapse of the shallow southern end of the tunnel led to it being opened up and shortened by 60 yards. It is known that a section of the tunnel collapsed in December 1790.

Contemporary reports state that the arch collapsed, not being covered in earth. This suggests that the south end was constructed using cut and cover while further into the hillside the tunnel was bored. It is believed there was one construction shaft which would have allowed four working faces during construction.

The euphoria seen on the opening day soon passed. There was initially some resistance to using the Coldwaltham Cut due to toll charges, and one boatman wagered a guinea that he could make it round the river in less time than by using the cut and tunnel. The river between Arundel and Pallingham was toll-free so charges for using the tunnel had to be reduced. The journey time between Littlehampton and Newbridge was about 2½ days with a saving of 6 hours by going through the tunnel. Barges with a light load continued to use the river which remained free of tolls.

The Arun Navigation was quickly in financial difficulties as the cost of construction far exceeded the estimate, and the expected carriage of 30,000 tons a year was never achieved with only 14,000 tons being carried in the first year; this barely covered running costs. The opening of the Rother Navigation in 1795 brought additional traffic along the Coldwaltham Cut.

The opening of the 18½ mile Wey and Arun Junction Canal between Newbridge and the River Wey in 1816,



1875 1:2,500 OS map showing Hardham Tunnel. With the arrival of the railway extension from Pulborough to Petworth in October 1859 the crown of the tunnel was only 13 feet below the track so an underpass was built to the east of the tunnel to avoid steam trains frightening barge horses that were being walked across Hardham Hill. When the double-track Mid Sussex line to Arundel opened in August 1863 a bridge was provided over the line to the west of the tunnel.

and the Portsmouth and Arundel Canal seven years later in 1823, completed the inland route between Portsmouth and London and brought additional traffic through the tunnel.

The Railways Arrive

Peak traffic on the Arun Navigation was reached in the 1830s with over 20,000 toll-paying craft passing through the navigation in a 60-year period with tolls collected from passing through the tunnel amounting to between a quarter and a third of the company's total annual revenue.

RIVER ARUN NAVIGATION,

(Twelve Miles)

Tolls to be Charged from the 1st of August, 1856.

TUNNEL TOLLS.

PER TON	Passing to and fro, including Coldwaltham Brook ...			
	Timber, Bark, Hoops, Coal, Culm, Corn, Lime, and Merchandize Goods	0	0	6
	Large Chalk	0	0	4
	Kiln Chalk, Grit, Ashes, &c.	0	0	3
	Stone for Building	0	0	6
	Stone, Flint, Gravel for Roads, Sand, and all Kinds of Manure	0	0	3
	Corn to Hardham Mill	0	0	3

JAMES POWELL,

Clerk.

There were individual peaks in 1858 and 1862 when the navigation carried building material for two new railway lines that passed over the tunnel; the railway being only 13 feet above the crown of the tunnel. To ensure that steam locomotives didn't frighten the barge horses, an underpass was constructed to the left of the tunnel beneath the track.

It was however the railways that would soon bring about the demise of the navigation. By 1868 revenue had plummeted with annual tolls dropping by two-thirds.

The only recorded account of a pleasure boat passing through the tunnel was in July 1867 when J B Dashwood, accompanied by Mrs Dashwood and their Pomeranian dog 'Boz', travelled from the Thames at Weybridge to the Solent via Littlehampton in their boat *Caprice*. Their journey through the tunnel from north to south is delightfully recorded in J B Dashwood's book *The Thames to the Solent by Canal and Sea* published in 1868.

> "About a couple of hundred yards from this spot, the river makes a détour of about five miles round by Pulborough, to avoid which a canal has been cut, passing through the chalk cliff by means of a tunnel. At the entrance of this tunnel we found another small lock, where we parted company with the pony, which had to go over the top, and meet us at the other end. This tunnel is a quarter of a mile long, 13 feet wide, the same in height, and cost £6,000. I punted the boat along by means of the boathook against the roof. In the middle it became quite dark, and we could only just guide ourselves by means of the bright outlet at the end.
>
> The roof was covered with stalactites, and in places the water fell upon us from crevices above in heavy drops, so that we had to try and steer clear of them where we heard their splashes on the water below. It took about ten minutes to pass through this subterranean passage,

The stalactites seen by JB Dashwood in 1867 didn't appear much longer in 2017. This is 125 yards from the south portal. Photo Kevin Roach

> and when we emerged on the other side, it was some moments before we became accustomed to the bright light of day.
>
> We were detained here some little while, for the groom had mistaken his way, and did not turn up for about twenty minutes after we got out of the tunnel. We recommenced our journey along a flat country, still in the Canal, until we reached Waltham Lock at about 12.30 P.M., where we found that the tide had, as we calculated, just begun to ebb."

Abandonment and Infilling

The Portsmouth and Arundel Canal was never a financial success and was abandoned in 1855 after only 32 years. The Wey & Arun Junction Canal closed in 1871 after just 55 years and this led to an immediate and inevitable decline in traffic on the Arun Navigation. Tunnel tolls dropped from £180 in 1871 to £70 in 1880 and by 1887 this had further dropped to just £10 with only five barges using the tunnel.

Hardham Tunnel south portal in 1949. Photo from Paul Vine collection

Official closure came on 1 January 1888 although tolls on the Upper Arun Navigation were collected until 20 June 1898 and on the Lower Arun Navigation until 29 January 1889 when the final barge loaded with 26 tons of flints passed through the tunnel. The two artificial cuts were officially abandoned on 21 September 1896, and an order

to wind up the company was made on 1 May 1897 in the Chancery Division of the High Court and the company was dissolved in 1899. Limited traffic continued on the old river sections into the 20th century, notably bricks from Harwoods Green below Pallingham and chalk from Houghton Bridge.

Two years after abandonment, passage through the tunnel was blocked. A letter in the *Sussex County Magazine* from Chas G. Saunders of Ditchling Road, Brighton explains how a section of the tunnel was filled up to the railway above to avoid future subsidence:

> I was with the Engineers Dept of the old L.B. and S.C. Railway at the time of the filling up of the tunnel beneath the railway tracks on the main and branch lines. The work was done by the Railway Co. in 1898. Holes were made a few feet from the running lines and carried down to the crown of the tunnel (9 ft. or 10 ft. below) which was pierced, and tons of chalk conveyed to the site by ballast trains were tipped down these holes, the chalk being thrown back under each railway to the extent of the Company's boundaries.
>
> I am now in my 81st year, and have been retired for 20 years from the position of Chief Clerk to the Civil Engineers Dept. of the Southern Railway, at Brighton station.

In 1898 the crown of the tunnel was opened by the LBSCR where it passed under the two lines and a section of the tunnel was infilled with clay. The shaft seen here was installed in 1942 to allow ongoing inspection of the tunnel. Photo Kevin Roach

Rural Explorers

After Dashwood's trip through the tunnel in 1867 the next recorded trip through the tunnel was by canoe in 1953 when two intrepid explorers, A. G. Marshall and W. Norris, ventured in; their account is recorded in the *Sussex County Magazine* in 1953.

> "At the northwestern (Rother) end, the entrance, though overgrown, was well preserved. The brickwork of the arch, and the abutments, were little damaged and part of the timber of a lock, just outside, remained. He was surprised at the small width of the tunnel, about 10 feet. The centre of the arch was about eight feet above the level of the water which, as it was here well above the level of the Rother, seemed to have accumulated by percolation and was about six feet deep. Only the narrowest of canal boats could have passed through. There was no sign of any ledge or horse-walk, and the only way of getting craft through must have been by poling or 'footing,' a process in which the bargees, bracing their backs against a deck-house or some other solid body, pushed with their feet against the walls of the tunnel. Embowered in trees and with ferns growing from the masonry, the entrance this side, though a little sombre, had the effect of a grotto and was not displeasing. Not long afterwards workmen on the pumping station scheme cleared the undergrowth and built a concrete dam across the canal bed a short distance in front of the tunnel entrance.

Hardham Tunnel north portal in 1952; Tunnel Lock was in front of the portal. In 1948, the North West Sussex Joint Water Board purchased 25 acres of land including the canal bed from the River Rother to the tunnel and new waterworks was built in 1952. A concrete dam was built by the north entrance of the tunnel on the site of Tunnel Lock and the channel linking the tunnel to the river used as a filter bed. Photo from Paul Vine collection

> Returning over the main railway, Marshall saw, beside the down track, a yard or so north of the girder bridge, a concrete hatchway with a moveable cover. He surmised, rightly as it proved, that this had some significance in relation to the tunnel.
>
> The southeastern, or Priory, end proved to be in a much more ruinous state. The abutments had gone and masses of brickwork lay all around. At some time there had been an attempt to block the entrance with a wall of blue clay, but it had subsided and formed only a v-shaped bank over which crystal-clear water from the interior slowly rilled into the lower level of the old bed through the fields. The scruffy atmosphere was accentuated by the fact that the place had long been used as a dump for old iron. Conspicuous were the remains of a hip bath, a milk churn and a coal scuttle, as well as an assortment of paint cans.
>
> Marshall could see, when looking down the tunnel from one position, a tiny spot of daylight. When he moved, the spot disappeared. This puzzled him. Apparently the bore of the tunnel was partly obstructed in some way, but how he could not imagine. The atmosphere of

the interior was very cold; the dripping of water could be heard, and when a train passed over, a couple of hundred yards away, every wheelbeat reverberated in the most sepulchral manner.

Expedition by Canoe

Obviously, further exploration was called for. A canoe, or one of those tiny 'pram' dinghies, would be suitable in size and easily transported. From canoes, Marshall's thought-process inevitably turned to colleague Norris, a young *Worthing Herald* reporter, veteran of several Sea Scouts canoe marathons from Pulborough to Littlehampton and builder of his own craft, the *Zephyr*. Norris jumped at the idea, and a joint reconnaissance was made.

Looking south along the tunnel from the south portal in spring 1979. Photo Nick Catford

It was agreed that the expedition should start from the northwest end of the tunnel, that sweaters should be worn as a protection against cold and that the pair should light their way by lamps slung round their necks. Norris said he could get the canoe forward – and backwards if they came to an obstruction – with a single paddle, as there was not room to use a double-bladed one. He kindly but firmly rejected Marshall's suggestion of a pole, to propel the craft gondola-fashion, and a boathook with which to draw it along by pulling on the brickwork.

For one reason or another, some time elapsed before the expedition could be made, but early one windy and rather overcast evening they set off. Marshall's small touring car proved almost ideal for transporting the canoe to the gate bordering the Midhurst railway. From there it was easy to carry it to the tunnel entrance.

Norris had no difficulty in setting it in the water and in taking his place in the stern. Marshall, though at home in boats on fresh or salt water, had inhibitions about the stability of canoes, due to an embarrassing experience before a Bank Holiday crowd on a park lake when a boy, and he took some time in lowering his fourteen stone, plus a shower of dry earth, into the forward seat. Lights were switched on, Norris flourished his paddle and the tunnel engulfed the pair.

Daylight waned rapidly. Almost at once they were conscious of the chill and of an earthy smell which, incongruously, suggested dryness. Drops of water fell on their heads and down their necks. The roof literally bristled with stalactites of a – to them – curious type. They were in the shape of little rods, greyish but sparkling in the lamplight, about a quarter of an inch in diameter and mostly between two and six inches long, though a few were a foot or more. They were found to be tubular, like macaroni, and filled with water. Apparently they formed from the inside outwards. They were very fragile and broke up when handled. Here and there Marshall and Norris saw a formation of more conventional shape, conical and of greyish chalky or limy substance.

After a short distance the tunnel was blocked with clay reaching up to the roof. Photo Norris and Marshall

Clay Mountain

All this was observed in a very short time and distance. They had progressed no more than about a hundred feet when a greyness loomed ahead and the lamps focussed on a miniature mountain of clay, scored and fissured, which rose out of the water, blocking the whole width of the tunnel and rising to the roof. They were, they knew, underneath the railway: they had thought of concrete or girders as a buttress to the road bed, but not this simple expedient.

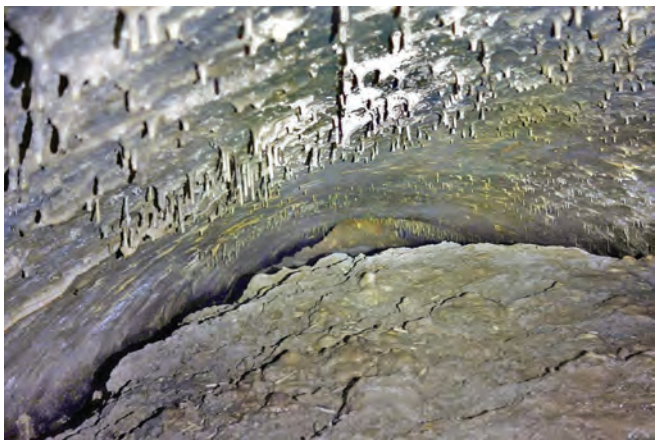
There was no sign of the roof having been opened up, but they concluded that it must have been, when the railway was cut, the clay tipped down and the track laid over the top. It was a ridiculous check to progress. Looking over their shoulders they saw the vivid picture of green leaves, set in a semicircular frame, only just behind. But their minds were made up. If the barrier was so near that end of the tunnel it was so much the farther from the other end.

When they got to about the centre of the tunnel practically every inch of brickwork was covered with some sort of deposit. The roof sprouted hundreds of stalactites of the kind they called macaroni; there were the conical type, too, some comically twisted

The south portal of Hardham Tunnel. The portal lacks a parapet and is comprised of a semi-circular brick arch with many of the wedge-shaped bricks (voussoirs) now missing. The portal is alongside a public footpath and has been accessed by a number of small boats in recent years. Photo from Wey & Arun Canal Trust

into the shape of pigs' tails, and those wavy growths, which, in the commercial, show-place caves, they call 'blankets.' These were mostly greyish, but a few were dull red and glowed with ruby brilliance when a light was focussed on them. In the spaces between the larger growths the brickwork was encrusted with a metallic or silica deposit which had the effect of aluminium paint.

Approaching the blockage from south portal in May 2017. Photo Kevin Roach



The first quantity of clay infill can be easily clambered over but beyond that the clay is up to the roof beneath the now closed Midhurst railway line. Photo Kevin Roach

Looking south from the clay blockage, 224 yards from the south portal in May 2017. The shaft up to the railway line is seen on the left. This was installed in 1942. Photo Kevin Roach.

Over their shoulder the pair saw the little patch of trees, framed in the opening, grow small, like a view seen through the wrong end of a telescope but increased in clarity. Just as the tunnel and the water in it had acted as a conductor of sound from the inside outwards, so did it conduct sound, with surprising clearness, from the outside world. Marshall almost jumped to hear a pigeon cooing, as it seemed near his elbow; when he got back, there was the bird cooing away in the trees by the priory, sixty or seventy yards away.

Heading back towards the south portal in May 2017, stalactites (or macaroni as Marshall and Norris referred to them) hanging from the roof for much of its length. Photo Kevin Roach

Flotsam or jetsam?

That was not the only odd thing about the tunnel. As they came in sight of the eastern face of the clay mountain, and realised that they were in as far as they could go, about three hundred yards, they found floating on the water a number of rusty but abnormally buoyant tins. Two looked as though they might have contained boot polish; another was flask-shaped and Marshall made out on it traces of the name of a brand of metal polish.

All were covered with a brownish, jelly-like growth; whether animal, vegetable or mineral, they were not able to decide. How had the tins got there? Had they

been carried that far by some easterly air current?

It was by accident, a chance gleam of light, that Marshall detected the oddest, and the prettiest, of all the odd things in that place. In a chink of the wall, he thought he saw something resembling gossamer with dew upon it: looking closely, he found that it was indeed a tiny cobweb, each strand sparkling with diamonds of moisture. It was a thing of sunshine and September mornings; how it came to be in that dark hole was the greatest mystery of all. Of the spider, or of any other living thing, there was no sign.

The canoe grounded against the mountain. On this side it was more furrowed into valleys and bays. In the right-hand corner of the largest bay – oh, the anti-climax of it! – ascended an iron ladder. It disappeared into a concrete manhole to emerge, no doubt, at the hatch which Marshall had seen beside the railway. It was through this hatch, as they confirmed by switching off their lights, that the spot of daylight percolated. The railway runs through a shallow cutting here, and cannot be many feet above the tunnel.

So they were not the first humans to go down there in eighty-odd years! That sinister-looking mass of clay had been trodden by the prosaic feet of railway gangers. But they consoled themselves with the thought that they were probably the first to sail those near-icy waters, so clear and yet so Stygian. With that in mind, Norris back-paddled and, in due course, they emerged. The sky had clouded over, dusk was falling and a gusty wind blew, but the air seemed very mellow and fragrant."

Hardham Tunnel north portal comprises a small parapet over a semicircular arch made from wedge-shaped bricks (voussoirs) and brick spandrels. Part of the left side of the face of the arch has collapsed. Photo from Wey & Arun Canal Trust

Approaching the south portal and daylight in May 2017. The tunnel remains in good condition throughout. Photo Kevin Roach

Grade II listing of the tunnel

"A tug of war" is how Paul Messis, a self-proclaimed history buff, described his battle with Historic England to get the agency to grant the disused Hardham Tunnel, listed status. Working with the Wey & Arun Canal Trust (the group aiming to restore the 23-mile canal that runs from Shalford in Surrey to Pallingham in West Sussex) Paul spent nearly three years in getting the importance of this unique structure recognised

Completed in 1790 Hardham Tunnel is one of very few purpose-made canal tunnels surviving in southeast England. Its presence became a fascination for Paul, who lived in Billingshurst, West Sussex, at the time. "I've always been intrigued by the geography of the landscape and often try to imagine what was in a certain place before, in history. When I came upon the initial depression in the landscape, I was curious about it and investigated further when I went home," he says.

His research led him to PAL Vine's *London's Lost Route to the Sea*, an historical account of the inland navigations which linked the Thames to the English Channel, written in 1965. When Paul found himself working near the northern portal his interest in both the tunnel, the disused canal and related railway lines became "almost an obsession". Paul relished the challenge of making an application to Historic England for listing of the tunnel.

"I feel it was important for me, because I guess I had a soft spot for Hardham Tunnel. It became one of the structures that seemed to me to be so mysterious and so uncared for, I wanted to get it listed for it at least to have some kind of protection and I suppose have a light shone upon it in some way."

Many email exchanges and much form-filling followed – with nine landowners along the tunnel it was never going to be easy. "To begin with, one simply had to email, fill out a lot of forms and then the process begins. I had to put together a portfolio giving reasons the Tunnel was

Hardham Tunnel looking south towards the south portal from the blockage beneath the Arun Valley railway line. The blockage is 224 yards from the portal. Photo Kevin Roach

important and why it deserved listing and this then had to be reviewed (a few times)."

Restoration and Celebration

Paul liaised with the Wey & Arun Canal Trust, a charitable trust which aims to restore the 23-mile canal which runs from Shalford in Guildford to Newbridge near Billingshurst in West Sussex, on some of the historical points and the process itself. Eventually Historic England went to view the tunnel. They subsequently submitted their own assessment to the Secretary of State.

Historic England's report deemed the tunnel to have both historic and architectural interest. "Historically it is a complete example of an early canal tunnel, as well as an unusual example of a canal tunnel built on an artificial cut forming part of a river navigation. Architecturally it is a good example of early canal tunnel construction, with simple portals reflecting the modest nature of the canal," it read. The tunnel was officially listed on 18 October 2019.

Paul says: "I was genuinely elated when the email came through to say it had been granted Grade II listed status. I was happy that I could do this for the local area and happy the structure finally got protection. My sincere hope is that it can be restored and opened up to the public so that other local history buffs like myself, weekend ramblers, tourists, schools and other people from the local area can enjoy, learn and experience it."

The north portal of Hardham Tunnel is within the Southern Water Hardham Supply Works. The south portal is below the footpath adjacent to Priory Cottages, London Road, Hardham.

At present the Coldwaltham Cut does not feature in the Wey & Arun Canal Trust's plans for restoration (see https://weyarun.org.uk/node/5) but Paul is hopeful that one day, the Coldwaltham Cut and Hardham Tunnel might once again form part of *London's Lost Route To The Sea*.

Sources:

London's Lost Route To The Sea. PAL Vine, 1965

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Hardham Canal Tunnel – Historic England Grade II listing, 18 October 2019

Gill Davies is the present Press and Publications Assistant for the Wey & Arun Canal Trust.

Nick Catford is a former Press and Publicity Officer for the Wey & Arun Canal Trust (c1980).

The Tunnels of Corregidor - Philippines

Tim Wellburn

The iconic remains of the 'Mile-Long' Topside barracks.
These were damaged in the Japanese air attacks and probably further so by the USAAF in 1945

Fortress Corregidor

Corregidor will be forever associated with General Douglas MacArthur's pledge: "*I shall return*". Made by MacArthur in March 1942, after President Roosevelt had instructed him to leave the Philippines ahead of its surrender to the Japanese, it was three years before Colonel George M Jones, commander of the US "Rock Force" operation to recapture Corregidor, was able to say to him, with equal brevity: "*Sir, I present to you Fortress Corregidor*."

Corregidor, or more correctly, the set of four fortified islands [1] lying across the mouth of Manila Bay, was a mighty fortress, comparable in many ways to Singapore [2]. The United States had seized the Philippines from Spain in 1898 after Commodore George W Dewey steamed into Manila Bay and destroyed the Spanish fleet. The construction of the American fortress was designed to prevent any enemy doing likewise. Work began in 1904 and was complete by 1917 - although a number of enhancements were made after World War I.

This was the "Endicott-Taft" [3] era in United States fort construction, characterised by standardised battery designs, built of concrete. On Corregidor, these mostly comprised pairs of guns mounted on disappearing carriages, but there were also two batteries of 12-inch mortars (one of four- and

General Douglas MacArthur,
commemorated at North Mine Wharf

Battery Cheney: One of the 12-inch guns, mounted on a disappearing carriage. This is a standard pattern Endicott-Taft battery. In the background is the traverse magazine and, elevated behind that, the battery command post; the second gun emplacement lies beyond the standing figure

one of eight mortars), grouped four to a pit.

Magazines were generally concrete traverse structures, set between the pair of guns or mortar pits. In all cases, protection was largely from direct fire: the batteries were designed to repel a naval attack at (then) long-range, not to survive close-range assault by howitzer; and, obviously, aerial attack was not a consideration in 1904. In 1942, both the latter were their fate.

Battery Way: A single-pit Endicott-Taft 12-inch mortar battery. The magazines, which are served by the tramway, are on either side behind the concrete revetment walls. The latter are of interest because they have been raised to provide greater overhead protection. The battery command post largely closes the fourth side of the pit

The forts were state-of-the-art when built but, other than limited additions between 1917-21, were not updated to keep pace with subsequent changes in military technology and tactics [4]. The 1922 Washington Naval Treaty prohibited the United States, Great Britain and Japan from building or reinforcing overseas bases, and the Great Depression cut deep into military funding. The defences of Corregidor and Manila Bay fared better than mainland USA coastal batteries, but Forts Hughes, Drum and Frank on the smaller islands were put on care-and-maintenance, and the fortress was not returned to 'active' status until June 1940, by which date it was obsolescent - and vulnerable.

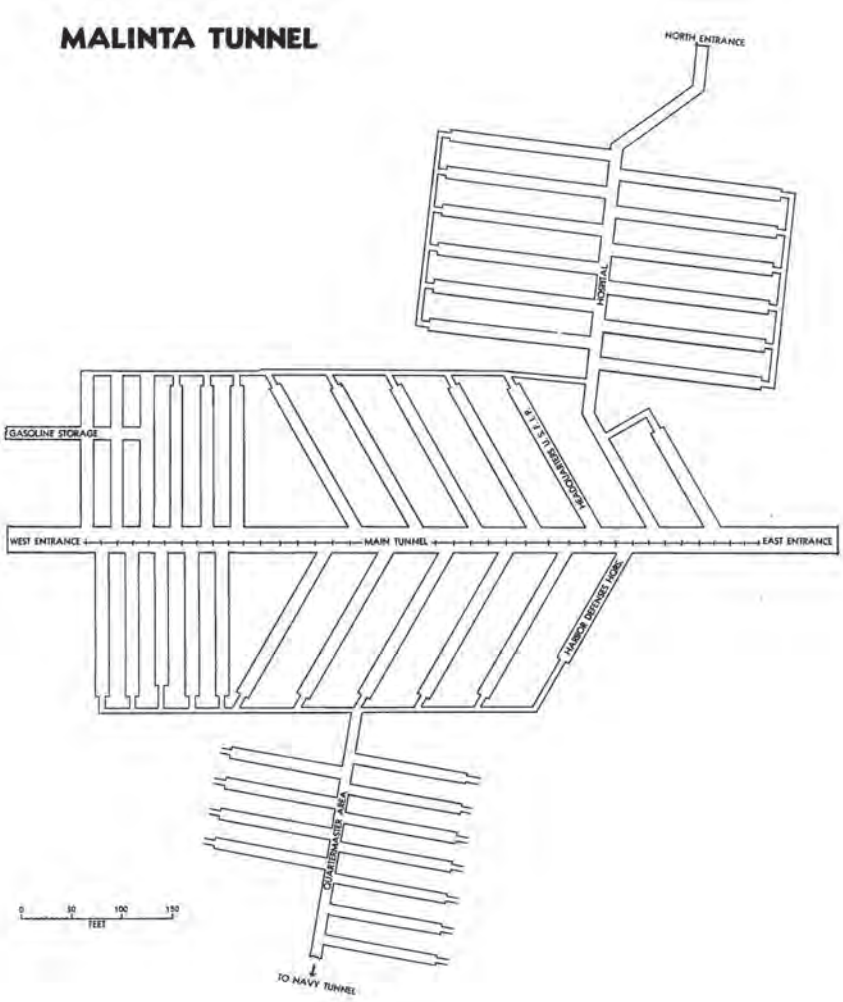
The Malinta Hill Tunnel

The eastern portal of the Malinta Hill Tunnel, giving a good impression of the mass and steepness of the hill - and the dense tropical vegetation which cloaks the island

There was one significant exception to this investment stasis. In 1931, work started on the Malinta Hill tunnel system. The purpose of the tunnel was to provide air-raid protection for personnel, equipment and supplies. This was clearly a proscribed defence enhancement under the Washington Treaty, so a certain degree of artifice was necessary.

In shape, Corregidor resembles a tadpole. In the western, 'core' part of the island, but not in the eastern 'tail', an extensive military electric trolley car (tramway) system linked the north and south wharves with the barracks, main storage buildings and batteries [5]. Separating the core from the tail was Malinta Hill, through which, obviously, it was necessary to tunnel in order to extend the trolley system any further east.

Malinta: the main spine tunnel viewed from the east entrance. Note the twin trolley tracks running its length



The completed layout of the Malinta Tunnel system, excluding the Navy Tunnels to the south, which were very largely destroyed, and for which there are no contemporary plans. Source: Wikipedia

No centrally budgeted funding was provided for this ('deniability' has a long provenance): the cost was borne locally, out of Fort Mills' maintenance budget. Filipino convicts were secured as the main labour force, and it is reported that condemned TNT from the Ordnance Department was shipped to Corregidor for use in blasting [6]. Excavation began from both sides of the hill.

By 1934 the first phase of the tunnel complex was complete. The spine of the system was a long (836 ft) straight main tunnel, running WSW-ENE, 24 ft wide at floor level and 18 ft high to the top of the arch [7]. It had plain but imposing concrete portals on either side of Malinta Hill: that at the West Entrance bears the date 1932. The trolley duly ran through the tunnel and for about 1000 yards beyond, to Water Tower Hill, where it served further officers' and barrack accommodation.

Branching off the main tunnel, on both sides, a series of lateral tunnels was driven (13 to the north and 11 to the south). At the western end, these were built at right-angles to the main tunnel; to the eastern end they were dug obliquely. I have not been able to find any explanation for this. The lateral tunnels were of smaller dimensions than the main one (approximately 150 ft /170 ft long by 15 ft wide).

Malinta: One of the laterals in the Gasoline Storage Area located in the northwestern part of the complex. The ends of these laterals were originally sealed off from the spine tunnel. This area has its own exit tunnel, a little way north of the West Entrance

Malinta: Air shaft in the southern part of the complex. Large sections of the tunnel ceiling and wall lining were demolished by explosions in this area

All these tunnels were concrete-lined because of the friable nature of the volcanic rock. Pedestrian-sized ventilation tunnels, not all lined, were dug parallel to the main tunnel to both north and south of this complex, linking to the end of each lateral tunnel [8]. The system was kept ventilated by large fans drawing in fresh air through air shafts. Illumination was by fluorescent lamps.

Extensions to the Core Tunnel System

Malinta: The hospital spine corridor with laterals, which served as wards (etc), opening alternately to left and right

Further tunnel systems were constructed subsequently, running further north and south of the initial complex. At the eastern end, a new spine tunnel was driven north with eleven laterals, of similar dimensions to the original laterals, to form a 1,000-bed hospital. Continuing in a dog-leg, this tunnel led to the North Entrance to the system, located on the coast road east of the main wharves, beyond Malinta Point.

Malinta: The North Entrance, leading to the hospital. Note the rather fine crest above the arch

To the south of the main complex, a Quartermaster (storage) area was built, consisting of a spine tunnel with eleven laterals of its own, four to the west and seven to the east. The original plan had been for a much larger facility with 16 laterals on each side of spine. The slightly awkward access to this area was from the eighth main lateral, with a slight change in heading across the ventilation tunnel.

Beyond this, possibly excavated as late as 1940-41, was the Navy Tunnel (or naval tunnel complex). The main Navy Tunnel ran out to an entrance on the coast road (Malinta's 'South Entrance'), just east of South Mine Wharf. However, there were other naval tunnels, only some of which are thought to have connected to the main one. The complex was very badly damaged by the massive explosions in 1945 and very little of this area now remains accessible: it was certainly off-limits for our visit [9].

Malinta: The (rather tired) stage-setting of part of General MacArthur's HQ in an oblique lateral at the eastern end of the spine tunnel

In June 1941, a few months before war broke out with Japan, provision was made for the secure accommodation of the President of the Philippines, Manuel L Quezon, and the government of the Commonwealth of the Philippines, in a lateral at the eastern end of the main tunnel complex. General MacArthur's Headquarters, which he later described as "bare and glaringly lighted", were located nearby.

The Japanese Attack, 1941 [10]

The Japanese 14th Army landed in Luzon, the main island of the Philippines, in which Manila is situated, in December 1941. The mix of land forces available to MacArthur was unable to halt the Japanese advance, so a strategic withdrawal was made to defend the

Middleside Barracks: the bombed shell of one of the former barrack blocks for enlisted men. The officers were accommodated in wooden houses, slightly higher up the hillside, which were an early casualty of the Japanese bombing. The barracks may have been further damaged in USAAF raids in 1945

Bataan Peninsula, immediately west of Manila Bay. On Christmas Day, MacArthur and President Quezon moved into their respective quarters in the Malinta Tunnel, joining a kaleidoscope of military personnel and civilians, including incomers to Corregidor who had evacuated other Philippine bases and facilities.

The Japanese fleet made no attempt to force a passage into Manila Bay, or even to attack Corregidor or the other coastal forts: the latter role was left to their air force. The air attacks, which started on 29 December, caused little serious damage to the gun batteries, but very considerable damage to the buildings and other surface infrastructure, including the water supply and trolley system.

By February 1942, the Japanese had emplaced artillery in Cavite on the southeastern shore of Manila Bay, reinforced by mid-March with 240mm howitzers. The forts provided counter-battery fire as best they could, hamstrung (as had been the British coastal batteries in Singapore) by inadequate spotting ability and ammunition largely inappropriate to the role they were now called on to undertake.

MacArthur departed Corregidor on 10 March. On 9 April the American forces in Bataan surrendered. The Japanese were now able to position heavy artillery to bombard Corregidor at short range from the west and started inflicting considerable damage on the fort's batteries. Notably, Battery Geary (eight 12-inch mortars) was wholly demolished when a 240 mm shell penetrated and detonated its magazine. The end now was only a matter of time.

Battery Geary: destroyed mortar mounts in the left hand pit of the battery. There is no trace of the traverse magazine, which would have been immediately to the right of these mortars

Conditions in the Malinta Tunnel complex had deteriorated badly by now, affecting morale. Two large-calibre shells had exploded near the entrance with over 60 casualties, but none had penetrated the system. The real problem was the air quality within the overcrowded tunnels which, in the tropical climate, depended critically on the electrically-driven fans to achieve a through airflow. The bombardments appear regularly to have disrupted the power supply, resulting in stifling conditions and long periods of darkness.

Having effectively silenced the American batteries, the Japanese landed on the tail of Corregidor on 5 May. Despite taking very heavy casualties, they established a beachhead. The Fortress surrendered the following day.

The Americans Return, 1945

Battery Wheeler: The Japanese restored No.2 gun by cannibalising No.1, but made no use of it. However, they turned the battery into a strong point and it was much damaged in the 1945 fighting. The picture is of the Battery Command Post, situated centrally behind the magazines

The Japanese garrisoned the Manila Bay forts with a little under 6,000 men, around 5,000 of whom were on Corregidor (the total US/Filipino garrison in 1940 had been about 14,000). They made only limited attempts to repair any of the batteries. By 1945, General Yamashita's strategy was to fight a holding withdrawal into the mountains of Luzon. Admiral Iwabuchi, on the other hand, decided to hold Manila and the Manila Bay forts.

Thus, on 16 February 1945, following air and naval bombardment, the Americans were forced to land on Corregidor, by parachute and amphibious assault. They achieved surprise and quickly secured their initial objectives, including the top of Malinta Hill, with few combat casualties. It then became a matter of systematically eliminating the myriad of entrenched Japanese positions. Many of these were established in magazines, tunnels or caves, including the Malinta Hill Tunnel complex.

However, on the evening of 21 February, before the Americans were able to launch an assault on this formidable strongpoint, the Japanese detonated a large stockpile of ammunition in the Tunnel, seemingly as an act of mass suicide. Further explosions occurred over the next two nights, completing their Malinta self-immolation. The damage to the tunnel system remains evident to this day.

Malinta Tunnel: Severe explosion damage, which has stripped out most of the tunnel lining, in part of the Quartermaster area

Malinta Tunnel: Damaged tank in the Gasoline Storage Area

The rest of the island was secured by the Americans - against some determined resistance by isolated groups of Japanese - over the course of the month, allowing General MacArthur's return on 2 March. The other island forts were retaken by mid-April.

Tunnels Built for Other Purposes

Malinta was, and remains, outstandingly the showpiece tunnel system on Corregidor, but it was far from the only one. Most of the others were late excavations, unlined, sometimes unfinished, and generally little documented. They are often almost lost in the jungle that is reclaiming much of the island, and access can be slightly sporting. The following sections describe most of the other tunnels I managed to visit: probably a reasonable sample of what may still exist.

Western Mine Control Station Shelter

At the smallest end of the spectrum is a small horseshoe-shaped personnel shelter located at the western extremity of the island. Its history is unrecorded, but as it is very near to the Western Mine Control Station, it is possible that the latter's crew deemed their protection inadequate and dug this tunnel shelter adjacent to the position. The two entrances are about 6 ft apart, with the date *1942* carved in cement between them. It most closely resembles a trial mine adit through dubious ground, and would not have resisted any near misses from incoming shellfire.

Western Mine Control Station Shelter: The two entrances to the horseshoe-shaped tunnel. The '1942' date is just discernible in the centre of the picture, above the backfill

Western Mine Control Shelter: Evidence that the inside is as small as the entrances suggest!

C-1 Tunnel

On a more formal and much larger scale, the C-1 tunnel is a personnel shelter located on the south coast, near Battery Boston (one of the 3-inch four-gun anti-aircraft batteries set up in 1941). It was dug in haste, in February 1942, for the aptly named Colonel Paul D Bunker and his staff. Bunker, a West Point class-mate of MacArthur's and college All-America football star, had tactical command of Corregidor's Seaward- and North & South Channel Defences. Like many others, he was to die in Japanese captivity.

C-1: The inside of the collapsed West Entrance

Western C-1: The spacious main tunnel with laterals on both sides

Beyond the final (facing) pair of stub laterals, the tunnel kinks to the left and becomes noticeably narrower. This section continues for another 40 yards or so to the former West Entrance, once reinforced with concrete, but now destroyed.

The central lateral on the southern side of the main tunnel is much longer, and of far more interest than the others. After about 25 yards it too kinks and narrows, at which point it turns into a rubble slope, at the top of which is a collapse chamber. John Moffitt has suggested that this is bomb damage to what was possibly a staircase to a southern entrance. If so, this would have emerged very close to Fort Mills' (ie Corregidor's) primary Command Post and the adjacent Gun Group Command Post [11].

The bunker has an irregular plan. The main part comprises a large, unlined tunnel of rectangular section excavated in the volcanic bedrock. From the eastern entrance this tunnel runs straight ahead for about 90 yards, with a number of laterals - mostly short - on both sides. The uneven rock-strewn floor suggests either a degree of instability or significant internal damage.

C-1: The western continuation of the main tunnel

Battery Smith

Battery Smith: The M1895 12-inch gun mounted on the more modern M1917 long-range barbette carriage. This elevated to 35 degrees, increasing the gun's maximum range to 27,600 yards. This was a gain of nearly 10,000 yards over the older M1901 disappearing carriage

Battery Smith was constructed in 1919-21, and is quite different in design to the original pre-war batteries. While its two 12-inch guns are of a similar type, they were mounted *en barbette* on high-angle carriages rather than on disappearing ones. Their magazines, engine and plotting rooms were subterranean structures, excavated behind the gun positions. The two gun emplacements were widely spaced and, in 1937, were reclassified as separate batteries (Smith & Hearn).

Battery Smith: The slope shaft looking up towards the entrance

Battery Smith (1937) is of particular interest because, uniquely, access to the gun is through a tunnel leading to the magazines, entered from higher ground behind. The tunnel entrance opens onto a long, concrete-lined slope-shaft, some 8 ft high by 10 ft wide, built with steps on either side of a central ramp.

Battery Smith: The lobby to the magazines and other underground rooms. The rubble underfoot is from the ceiling where scavengers have removed rebar for its scrap value

At the bottom of this slope-shaft, magazines and plant rooms were excavated off to the left. The tunnel continues straight ahead, now on the level, emerging at the back of the gun platform. This section seemed to have served as a crew shelter, but the lack of any blast protection is surprising.

Battery Smith: One of the impressively long, but perhaps less than ergonomic, magazines

Middleside Tunnel

Middleside Tunnel: the largely backfilled portal

This ambitious - but unfinished - project was a late attempt by the Americans to excavate a tunnel from the Middleside barracks and officers' accommodation, running below Topside, to emerge, presumably, at some point adjacent to the facilities and/or batteries lying to the south. The tunnel commences just above the site of the former officers' housing at Middleside, and is accessed by a path contouring from near the bottom of the "Golden Staircase" [12].

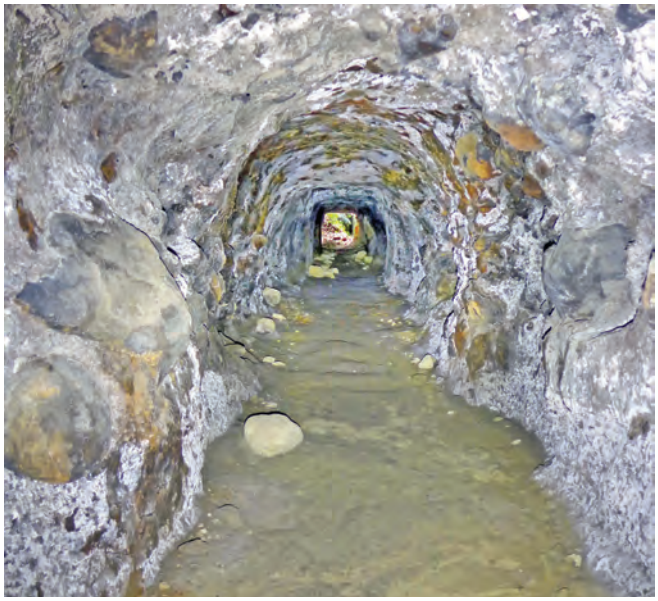
Middleside Tunnel: The tunnel is quite generously proportioned, as can be judged from the figures just visible in the distance

Once again, the tunnel entrance has been largely backfilled. Inside, it is rock-cut, with a square or rectangular cross section. There are a few short laterals, set at right-angles to the main tunnel, one of which contains a number of rusted steel drums. This may evidence storage usage – perhaps because it was never completed to serve a communication function? The tunnel comes to a dead end after 200-300 yards. At one point, melted rock on the tunnel wall provides evidence of fierce local combustion.

Middleside Tunnel: One of the laterals, evidencing a storage function at some period

On a minor chord, there is a series of short tunnels or shelters, of various dimensions, excavated under one of the barrack blocks at Middleside. Their provenance is unknown. They are accessible through metal trap doors set in the floor, but shortage of time precluded exploration.

The Japanese Tunnel



Japanese Tunnel: looking back to portal from near the point at which it climbs steeply to surface

On a rather less ambitious scale, but of similar rock-cut construction to the Middleside Tunnel is the Japanese Tunnel at Topside. This too appears to have been a communication (or possibly shelter?) tunnel. The lower end opens in a small rock bluff near a trio of large US Quartermaster Store Buildings, but its nature is not really compatible with the movement of goods or materiel.

Japanese Tunnel: the crude flight of steps. The 'doorway' at their head is the bottom of the short shaft

From here it runs straight into the hillside for perhaps 100 yards, and then abruptly ascends in a run of large, crudely rock-cut steps. These lead to a 6 ft vertical shaft, which emerges within an American battery (or mine?) control post. As the Japanese were unlikely to have been utilising this building for its intended purpose, it must simply have served as a convenient 'hardened' exit to the tunnel.

Japanese Tunnel: The head of the shaft, excavated in the floor of an American control post

Wheeler Tunnel

This tunnel system, located just to the west of Battery Wheeler, is something of a mystery [13]. No one has ever found any documentation showing when or why it was built. Apparently, it first appears on maps from the early

Wheeler Tunnel: The main corridor at the higher level, into which the personnel shaft opens

1920s, but might not have been built/completed then: as noted above, the 1921 Washington Treaty stopped work on (overtly) military projects.

It has been suggested, given its location and relative complexity, that it may have been an early 'fortress command' for the harbour approach defences: it is known that it was not included as part of the infantry or beach defence schemes. Although adjacent to Wheeler Battery, the latter was a standard Endicott-Taft design, incorporating a battery command post, crew shelter and magazine, so there was no call to duplicate or supplement these elements with a separate underground facility.

Wheeler Tunnel: The personnel shaft

We entered the tunnels via a narrow vertical shaft, perhaps 20ft deep, set with widely-spaced iron hoops, which

Wheeler Tunnel: The curious sloping storage passage

dropped into a wide corridor. Inside, it is something of a three-dimensional labyrinth. Largely concrete-lined, the tunnels and chambers are arranged on an irregular pattern and incorporate some unexplained features.

Wheeler Tunnel: The narrow and rather rudimentary flight of steps which leads to the lower level of the complex

The profile of the tunnels is unusual in that the upper part of the walls have an angular inward cant, presumably for additional overhead strength. However, this has not prevented a hit by a bomb or shell causing a roof collapse at one point.

A unique, and unexplained, feature of the complex is a sloping passageway, lined on each side with a series of short parallel platforms. Presumably, these were intended for low-level storage (possibly of drums? - the wall profile precludes conventional racking) - although, given the slope, handling must have been difficult.

A internal flight of concrete steps runs steeply down a crudely excavated slope shaft to a lower level from which a broad concrete passage runs out to daylight very near to the cliff face. The contrast between this link and the neatly-finished concrete-lined sections of the complex suggests that it was excavated later, and in a hurry. Elsewhere there is a rectangular concrete shaft which, from its dimensions, seems likely to have been intended for equipment or materiel rather than personnel. A map of the island shows at least one other portal, nearer to Battery Wheeler, but this now seems lost in a collapse. Fighting in this area in 1945 was particularly fierce.

Wheeler Tunnel: The lower, cliff-side entrance. It is unclear why the portal remains unlined

Navy Radio Intercept Tunnel

From 1939, the US Navy operated a secure signals interception facility, south of Kindley Landing Field in the tail of the island. On the surface was a network of wooden masts from which the antennae were hung (the circular concrete bases with a few splintered remnants of the masts survive), but the nerve centre of the facility was underground [14]. This was comprehensively wrecked in February 1945 by the Japanese detonating explosives in a mass suicide which also caused many casualties among the American troops who had just reached the position.

The entrance to the intercept tunnels resembles a bomb crater, but access is still possible through a very small hole, dropping onto the top of a steep debris slope, which can be negotiated with the aid of a rope. Originally, this would have been a staircase leading to the main lateral of the complex.

Navy Intercept Tunnel: The author contemplates the access hole, while Andy Grant secures the necessary rope. Photo Mike Fiorini

Inside all is rubble and desolation as the explosion destroyed sections of the tunnel and most of its concrete lining. At the foot of the entry slope, on either side, are short spur tunnels, but only the arches of these remain open - and are not inviting. At the end of the main lateral, running to both right and left, is - or was - the complex's main tunnel.

To the right the tunnel lining has been completely blasted away and access seemed to be blocked after a short distance by a debris pile. This may be the bottom of the large (man-sized) concrete-lined ventilation shaft seen

Navy Intercept Tunnel: The debris slope which was once the side entrance stairway into the main lateral

on the surface. I chose not to explore in that direction. Somewhere beyond this lay the main entrance portal - now a crater. To the left, the main tunnel still has some remaining sections of (degraded) roof lining and can be negotiated with caution for a little way. At the far end was another exit staircase, now lost in a collapse.

I returned whence I had come, back up the rubble slope and out of the hole - exiting was rather harder without gravity assistance - and for once, I have to say, it was a pleasure (and something of a relief) to return to the surface.

ACKNOWLEDGEMENTS

By various accidents of history, Corregidor contains one of the best collections of turn-of-the-century American coastal artillery surviving in situ anywhere. Much of it takes some finding: only a few of the batteries and a small proportion of the buildings are tidied-up and preserved for day-trip visitors; tropical vegetation is increasingly cloaking the greater part of this once mighty fortress.

I was fortunate to visit the island with the Coast Defence Study Group, in the good company of some very enthusiastic and knowledgeable people who were happy to share what they had found and learned over the years: any errors in this article are entirely my own.

I am grateful to Glen Williford, who organised and led the CDSG Tour, and to Andy Grant and John Moffitt who, on several occasions after the conclusion of the day's main visits, were happy to hack through the wilderness to trek to other fascinating structures, including several of the tunnels described above.

All photographs are by the author, unless indicated otherwise.

Fort Drum: The US Corps of Engineers sliced the top off El Fraile Island, excavated its interior, and encased the whole thing in concrete. They installed two turrets on the 'deck', each mounting a pair of 14-inch M1909 guns and, on each side, a pair of casemate-mounted 6-inch M1908 guns, one above the other, in pre-Dreadnought style. The port-side 6-inch casemates are just visible at the extreme right of the photo

NOTES & REFERENCES

[1] The fortified islands of Manila Bay were: Corregidor (Fort Mills); Caballo (Fort Hughes); El Fraile (Fort Drum - the famous "concrete battleship") and Carabao (Fort Frank).

[2] In both Manila Bay and Singapore, the fortress artillery was designed, located and equipped to deter an attack by enemy naval units (and succeeded in doing so). Defence of the respective hinterlands was the responsibility of other military arms. Like Singapore's (more modern) batteries, many of those in Manila Bay were pressed into a last-ditch land-side defence, for which they were not intended or well equipped. Almost all the US and British batteries were disabled by their crews before surrender. In neither territory did the Japanese make any significant effort to reinstate them.

[3] The "Endicott-Taft System" was named after two Boards or committees, which published seminal reports and recommendations on United States seacoast defence. The 1885 Endicott Board established the Endicott Program which, modified by the 1905 Taft Board (taking into account electrical technology and advances

Ordnance Building 41, with a trolley loading dock. The date 1915 is inscribed on an elaborate pilaster (here hidden from view by a fallen tree)

in fire control, together with the need to defend new overseas territories - including the Philippines) became the Endicott-Taft System, the blueprint for US coastal defence until its demise post-WWII.

[4] Between 1917-20, nine 3-inch gun batteries were built on Corregidor (Fort Mills), seven of which were anti-aircraft batteries. A more modern heavy gun battery, Battery Smith, was also constructed (1918-21). This comprised two 12-inch M1895 guns on M1917 "long range" (ie high angle) mountings.

[5] Tony Feredo, *The Corregidor Railway System*, Historic Corregidor, Corregidor Historic Society

http://corregidor.org/chs_feredo/rails.htm

The electric trolley network was the second rail system built by the US Army Corps of Engineers in Corregidor. The first had been a temporary 3 ft-gauge steam locomotive- (and winch-) hauled construction railroad. The trolley system, designed to service rather than to build the fortress, followed different routes with gentler gradients. It was 3 ft 6 in gauge and ran on 600 volts DC, supplied through overhead wires. A free passenger service was operated by trolley cars which would not have looked out of place downtown in a US city. There were also freight movements. The system was badly damaged by the Japanese bombardment, and much of it was subsequently scrapped by them to support their war effort. All that remains today are a few loading docks and the occasional run of 'ties' (sleepers) on overgrown pathways that follow some of the old trolley routes.

[6] Paschal N.Strong, *The Lean Years, Historic Corregidor*, Corregidor Historic Society

http://corregidor.org/chs_lean_years/leanyear_01.htm

[7] For comparison, "The Great North Road" vehicle tunnel in Gibraltar is 15 ft wide, with a height of 14 ft, albeit with frequent long passing bays.

[8] A similar "back drive" ventilation arrangement was used in the Gibraltar tunnels, although in Gibraltar's case, the pervious nature of the rock meant that all accommodation and storage had to be in Nissen, Iris or truss-roofed concrete buildings erected within the chambers, which were closely contoured to accept them.

[9] John Moffitt and others have explored, measured and photographed what remains accessible of the Malinta Navy Tunnels. His reports, with some plans, are on the Corregidor Historic Society website:

John Moffitt, *Malinta Navy Tunnels (Parts 1 & 2), Rediscovering Corregidor*

http://corregidor.org/chs_moffitt/malinta_navy_01.htm

[10] For the chronology of events, and other information on the fortifications, I have drawn on Wikipedia and, more particularly, on the excellent monograph by CDSG members Mark Berhow and Terry McGovern:

M Berhow & T McGovern: *American Defenses of Corregidor and Manila Bay 1898-1945*, Fortress 4, Osprey 2003.

[11] John Moffitt, *Re-visiting the C-1 Tunnel, Field Note, Rediscovering Corregidor*

http://corregidor.org/fieldnotes/htm/fots2-100427.htm

[12] The "Golden Staircase" runs from between Middleside and Topside, the two main military accommodation areas in Corregidor. The latter was also the Fortress Headquarters. The route was originally a cable-hauled incline, built to transport construction materials, continuing the cable route up from Engineers' Wharf.

[13] I am indebted to Glen Williford, one of the acknowledged experts on Fortress Corregidor, for sharing with me what he knows about the enigmatic Wheeler Tunnel and his further deductions regarding it, and for allowing me to recount both of these here.

[14] In 2011 the ever-intrepid John Moffitt explored the Navy Radio Intercept Tunnel complex far more thoroughly, and photographed it far better, than I managed to do. I consulted his *Field Note* in writing my description of the original plan of the facility:

John Moffitt, *The Navy Radio Intercept Tunnel, Field Note, Rediscovering Corregidor*

http://corregidor.org/fieldnotes/htm/fots2-110423-1.htm

National Service in the Royal Air Force - 100 feet Underground

John Tysoe

The Filter Room at RAF Box in 2008. The floor of the filter room was overlooked by a mezzanine observation floor. Some of the original green and yellow paint is visible; this colour was chosen not to distract the operator. The Sector Operations Room was through the opening on the left. Photo Nick Catford

On 13 May 1952, I left Northampton to commence my National Service in the Royal Air Force. I had no idea what lay ahead although I had, prior to conscription, indicated a preference for aircrew.

Sometime in the afternoon the train steamed into Warrington station, where an RAF lorry was waiting to transport me and several others to RAF Padgate (now an industrial estate just off the M6 motorway). On arrival at Padgate we were 'kitted out' and those who had applied for aircrew were shown to our accommodation.

Selection and induction

The next day after initial induction we were transported to Warrington railway station en route to RAF Hornchurch in Essex, the selection centre for aircrew. After two days of tests – medical, written and oral – we had final interviews. I had failed the aptitude test – only Fighter Pilots were required which I did not fancy. I said my preference was Transport Command.

So it was back to Padgate, and then to RAF Hednesford for six weeks 'square bashing'. Whilst there I was allocated to Fighter Control to become a Fighter Plotter, as were all those who had failed aircrew selection; I do not recall being offered any alternative.

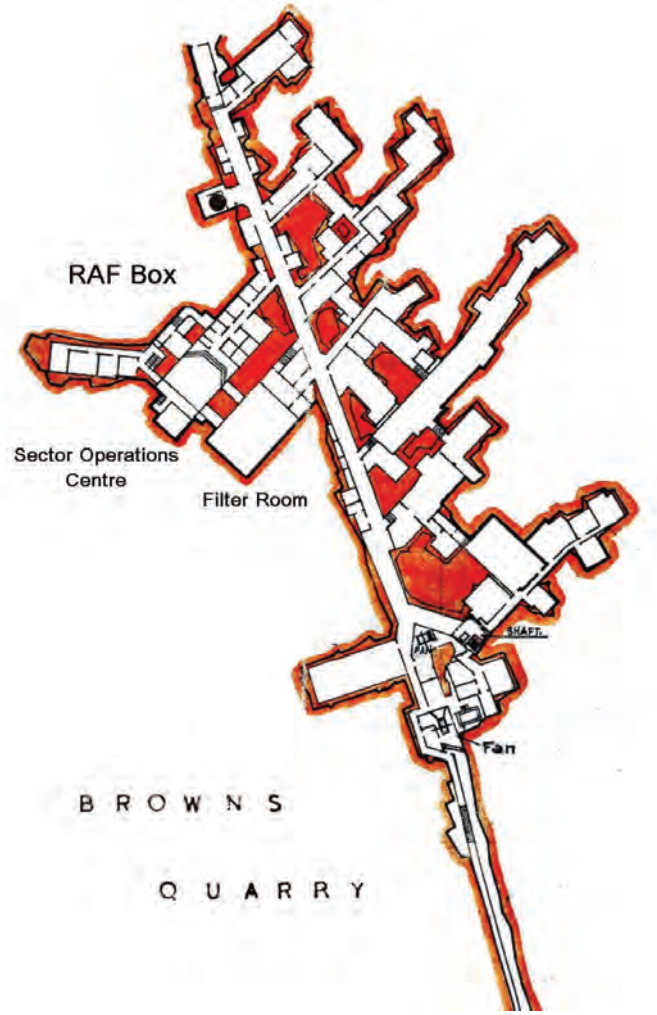
After six weeks, those allocated to Fighter Control were taken to RAF Middle Wallop, for a four-week training course in Fighter Plotting. Middle Wallop was in a lovely part of Hampshire and the airbase was mainly used for practice interceptions.

The aeroplanes were mostly Oxfords and it wasn't too difficult to get a ride on one of the flights. I remember circling Salisbury Cathedral countless times without intercepting another plane.

RAF Box

From Middle Wallop we were sent to RAF Box, part of No. 11 Fighter Group. The main base was RAF Rudloe Manor with the barracks at RAF Hawthorn. Box

RAF Box Sector Operations Room in November 1944. When John Tysoe arrived in 1952 the layout remained the same



was above ground and housed a comparatively small command post with just a couple of outbuildings. The command post housed the RAF Police and two lift doors.

On descending in the lift approximately 100 feet you arrived at a wide passageway, which sloped gradually for perhaps two or three hundred yards to a small doorway which led to RAF SW Signals, strictly off-limits.

Leading off this large corridor was the NAAFI, which was open nearly all the time, as shift work was the norm, and the telephone exchange which was quite substantial. Also the Filter Room, where information from Radar stations in the southwest was filtered on maps for transmission to the adjacent General Situations Map (GSM) room.

The GSM was where the information from the Filter Room was transferred onto the map by plotters for the controllers, from an overlooking balcony, to decipher and assess action required. To assist them there was an Operations Board which contained the state of readiness of the two airfields under the control of Box. These were RAF Tangmere (Meteors) and RAF Odiham (Vampires).

A right fix

There was also the Fixer Room, which supplied the position of aircraft to RAF Sopley. This information was obtained from several Direction Finding (DF) stations in the southwest. DF works by triangulating radio transmissions received by ground stations from the target aircraft. The Fixer table was a map of England with a graduated ring in the centre. In the middle of the ring were several 'pull outs' (cords). Around the table were stations connected to the DF stations.

When the operator received a bearing he/she would pull out the 'cord' to that bearing. If three or more stations recorded a bearing, then where they all crossed would be the position of the aircraft; the Fixer Controller would then pass this on to Sopley.

Emergency exit route from the two chambers in 2008. Photo Nick Catford

This would be called an Able Fix, whereas if only two bearings crossed this would be a Baker Fix. (Able and Baker were the phonetics for letters A and B before the NATO alphabet with Alpha and Bravo was adopted in 1956.) Sometimes a reciprocal bearing occurred, which, of course, presented confusion.

We were told that even the locals did not know of the existence of these underground operations, but to see a squad of men enter a small building and not emerge until eight hours later must have raised questions.

CAD Corsham and demobilisation

The walk/march between Hawthorn barracks and Box passed by Central Ammunition Depot (CAD) Corsham, which was also underground; in fact the working area of Box was virtually directly above one of the largest ammunition depots – quite a thought!

John Tysoe (right) at RAF Box

When returning from weekend leave, I got off the train at Corsham station and had to walk through CAD Corsham to get back to RAF Hawthorn. Talking of weekend leave, the norm was to catch the 6.10pm *Merchant Venturer*, from Chippenham to Paddington, which got me back to Northampton around 10pm.

Also adjacent was HMS *Royal Arthur*, an underground storage facility for the Royal Navy. The 'sailors' based there enjoyed the same privileges as those at sea, i.e. very cheap cigarettes which was a bone of contention for us airmen.

During my time at Box we had visits to Ventnor Rotor station on the Isle of Wight and RAF Portland, Verne Rotor station. To get to the latter we had to go through The Verne prison area.

The access tunnel to RAF Portland, the only ROTOR station to use London Transport tube linings. Photo Nick Catford

All in all I was at Box for about 18 months, and I suppose my interest of things underground started there. On demobilisation I was glad to get back to a normal way of life, although I would not have missed the two years National Service for anything; it was just an interruption in one's career.

Throughout the Fifties, Cold War tensions rose and although my interest in underground things was still there, there was no chance of any visits to military sites as all bases were classified. It was fortuitous that the public at large were not fully aware how close we were to World War III or annihilation, as it would have been.

Living in the Midlands there was plenty of aeronautical activity nearby, with bases such as RAF Upper Heyford and RAF Alconbury, surface-to-air missile sites and a number of US Air Force airfields.

In the Sixties quite a few RAF stations held public open days. One I will never forget was at RAF Gaydon and seeing (and hearing) a Vulcan bomber take off virtually vertically; the ground literally shook.

Back Underground

In the Nineties I began to make enquiries about visiting Rudloe Manor. After exhaustive efforts I eventually

made contact and a visit was arranged. By this time CAD Corsham had closed and all ammunition had been removed. Basil Hill Barracks was still active and the site was used for Joint Service Communications.

There was a small party and we met at the guardhouse at RAF Hawthorn. We crossed the road and into the top end of Basil Hill and entered a small building where a lift took us down into the former CAD and an area which was the Bristol Aircraft Factory during WWII.

We made an extensive tour of the depot and in one of the cavernous storage areas Andy, our guide, switched off the torch – no electric lighting, and we were plunged into TOTAL darkness, absolutely no light. Quite eerie! We also visited the loading platform where ammunition was transferred to the conveyor belt system which took the weapons to the vast storage areas.

Standard-gauge platform where trains arrived through Box Tunnel. Photo Nick Catford

Loading railway wagons during WWII

The loading platform was accessed by a siding next to the entrance to Box Railway Tunnel, which is on the old Great Western Railway (GWR) main line between London and Bristol. At the end of the loading platform was an engine shed for repairs to the small diesel locomotives which hauled the wagons into the Depot. There was even a small subterranean turntable. That was a fascinating visit, and as often is the case, left me wanting another!

Box to the Future

The opportunity came a couple of years later, as I had expressed a wish to visit Box, where I worked in Fighter Control. It was great to do a repeat of the previous visit, but this time to go through to SW Signals and into the corridor that sloped down from the lifts at RAF Box.

The access corridor in 2008. Photo Nick Catford

From the corridor a flight of steps lead into the Sector Operations Room: Photo Nick Catford

Oh what a sad sight. The corridor itself was much as I remembered it, but nearly everything off it was just a derelict mess. Walls and ceilings were ripped away exposing the rocks and stone which were the original excavations of the mine workings for the extraction of Bath stone. We went into the Filter Room, the GSM

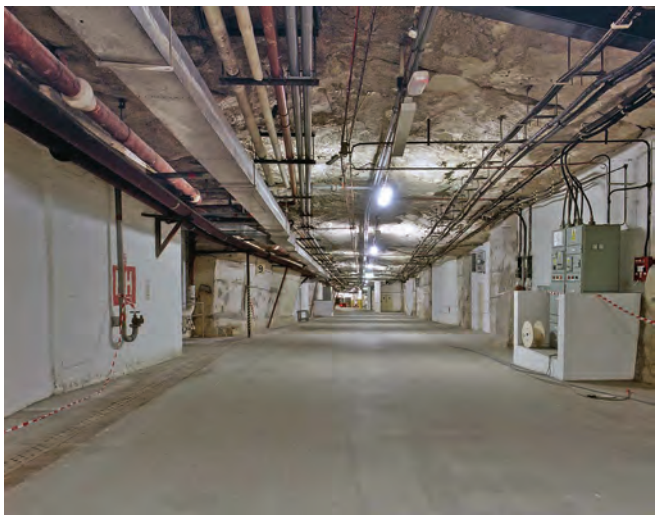
The Sector Operations Room in 2008, the filter room is through the opening on the left. The gallery was removed in the late 1980s and the room is now little more than a shell. Photo Nick Catford

The Filter Room in 2008 seen from the raised mezzanine floor that overlooked the room. The two chambers were each fifty feet square and forty-five feet high. Photo Nick Catford

room including the room in which I took my SAC (Senior Aircraftman) examination, all stripped of fittings. Very sad.

On our way back to the CAD lifts I asked Andy: Was there any truth in Burlington (still classified at that time). Andy replied, "There was never a Burlington, there isn't a Burlington, and there will never be a Burlington." What an admirable statement when it was only the other side of the wall!

Into the early 2000s it was obvious that the time was fast approaching for the questions raised regarding a secret place under Box Hill to be answered. Around 2003 Burlington was declassified, and I started to pester the Commanding Officer of the Joint Security Co-ordination Centre (JsyCC) at Basil Hill, to see if there was any chance of a visit. After many goes he eventually referred me to Andy (our guide on previous visits to CAD Corsham), and a visit was arranged.



One of the 'proper streets' in Burlington in 2006. Photo Nick Catford

Third (and fourth!) time lucky

I think it was 2005 when I finally managed to visit Burlington. One again I met Andy at the Guardhouse at the old RAF Hawthorn. We went down in the same lift as we had used on the previous visit, only this time we went through an area we hadn't been in before and a whole city opened up. Proper streets with signposts and a golf-type buggy for transport. Obviously the area has been recorded many times, but it was awe inspiring!

To walk into one of the largest telephone exchanges I have seen, with tiled floor and a complete set of telephone directories for 1963; there was also a directory of names of Members of Parliament for 1963. The block of PTTs (Pneumatic Tube Transport) was absolutely amazing. The canteen, the offices complete with office chairs, still wrapped in protective cover, the stores with furniture. An incredible place!

I was fortunate to visit Burlington a second time, this time with my movie camera, in pre-digital days. Such a pity that current regulations prevent this marvellous piece of engineering and all the surrounding sites being opened and available to a wider audience. Hopefully they can be preserved either in the form of business premises or just for historical reasons.

The telephone exchange in Burlington

Editor's note: See *Subterranea* 22 (April 2010) : TOP SECRET ACID – The Story of the Central Government War Headquarters 1936–2008; and Burlington - *The Central Government War Headquarters at Corsham*. Folly Books 2012.

A number of key sections of the standby government headquarters including the former CAD in Tunnel Quarry are now scheduled ancient monuments and have statutory protection. The Olga Lehmann murals in the Quarry Operations Centre are also listed Grade II*. Although this prevents their development or destruction, it sadly doesn't guarantee their ongoing maintenance or allow public access.

Paddock - an Open and Shut Case

Bill Ridgeway

When Sub Brit members first visited Paddock in 2001 the lower floor was flooded to a depth of 16 inches. Photo Nick Catford

Background

Paddock is a two-level underground bunker in Brook Road, Dollis Hill, northwest London, which was built in secret as a standby Cabinet War Room in World War II. This article covers the most recent phase in the history of the bunker from May 1997 when Network Homes (at the time Network Stadium Housing) acquired part of the site from Evans of Leeds for social housing development. Planning consent was granted (subject to outline conditions) by Brent Council on 11 November 1997. [1]

One of the conditions was a requirement to open Paddock for public open days at least twice a year "*to celebrate the history of this locally listed building and its site and ensure satisfactory public access*". [2] The conditions were agreed and planning consent for housing was granted by Brent Council on 22 December 1999. The whole of the area described as "Former Post Office Research Station, Gates & Bunker, Brook Road" was on a list of locally listed buildings by 1984 and afforded a measure of protection. [3]

Sub Brit gets involved

Members of Subterranea Britannica (Sub Brit) first visited Paddock on 19 April 2001 and again on 17 May 2001. We entered through what is now referred to as the south emergency exit. There was no lighting other than torchlight. On descending the stairs to the lower level we encountered water to a depth of about 40cm (16 inches). Not to be daunted and having taken reasonable precautions we proceeded to investigate, probing for trip hazards and voids as we progressed. One member avoided getting his trousers wet by the simple expedient of taking them off.

The surface building at Paddock survived until Network Homes acquired the site in 1997

A Vera Lynn look-alike welcomes visitors on the first public and press open day on 17 April 2002. Photo Maria Michael

Teleprinter room seen on the day of the first Sub Brit visit in 2001. As well as 16 inches of water on the floor, the teleprinter tables running around three walls are covered in mould and there is mould hanging from the ceiling. There is a message hatch in the far wall for passing teleprinter messages to the adjacent room which is believed to be the cabinet office. The teleprinter tables have now collapsed leaving only the frames. Photo Nick Catford

Some walls in the bunker had a thick covering of mould which remained for several years of public open days. We were told that if undisturbed the mould was not a hazard to humans and visitors were asked not to touch it. It was fascinating to explore the site for the first time – a fascination that has remained until the present day. Up to this point only limited research on the design, construction and uses of Paddock could be undertaken but now hands-on research could start.

Public open days

It was agreed that the responsibility for organising open days would be shared. Sub Brit became responsible for providing Tour Guides (who provided a commentary) and Marshals. The latter ensured the visit progressed safely, that no one got lost or left behind and also helped answer visitors' questions.

Network Homes staff were responsible for administrative matters. These included maintaining and preparing Paddock, taking bookings and (most generously) providing refreshments and toilet facilities for Sub Brit helpers.

Network Homes installed electricity and pumped water from the sub-basement (at a cost of around £15,000) towards the end of 2001. The first public open day was 17 April 2002 which was well attended and enhanced by a Vera Lynn look-alike.

Worldwide interest

Much publicity was generated that day and TV and film crews turned up from all over the world – including Reuters – which publicised Paddock worldwide. Enquiries for bookings for subsequent public open days came from home and abroad (in particular from America and Germany) with some people even planning their holiday around a public open day.

This started a cycle of two open days a year, one usually a weekday in May or June and the second on the Saturday in September that aligned with the London 'Open House' programme. The midweek opening always included lots of visits by local schoolchildren, who had World War II on their curriculum.

On the public open days Sub Brit provided tour guides and helpers while Network Stadium Housing took the bookings. Maria Michael who was PA to Networks CEO attended all the open days and dealt with registration on the day. Maria left Network in May 2004 but stayed on as a helper until tours were suspended. Her place was taken by Katy Bajina who was the new PA to the CEO. Photo Nick Catford

A number of local schools booked tours on the midweek open days. Photo Nick Catford

Each event attracted 400 or so visitors, split into groups of up to 25. Up to 20 Sub Brit members attended each event as helpers, and many friendships were struck through helping out in this way. It was also an opportunity for Sub Brit to sell a few publications and even recruit new members. In total over 12,000 members of the public were guided round the site.

Site safety

The first job of the day for Sub Brit helpers was to do a site check to ensure visitor safety. This included checking all the lights were on, checking the pumps were working and sweeping any surface water in the sub basement into one of the two sump pumps – which could take two helpers as much as 45 minutes. Any obstructions were moved off the tour route; for example, on a couple of occasions original light fittings and conduits had collapsed.

The meet-and-greet team (armed with a list of visitors with pre-booked tickets for specific tours) organised visitors into tour groups of a maximum of 25 visitors for each tour. Real-time management was made more interesting by a number of variables.

Senior guide Andrew Smith delivers some well rehearsed information at the top of the spiral stairs on the upper level. Photo Les Burrell

Visitors head down one of the narrow spiral stairs to the lower level. Photo David Merrigan

The Jubilee line service was suspended on a number of September public open days and visitors who could not use the closest tube station (Dollis Hill) had to make alternative journey plans. Visitors arriving early or late were shoe-horned into vacancies. There were also the inevitable no-shows. In addition there were people asking *"I don't have a ticket but can I go in?"* who were accommodated wherever possible.

With tours of up to 25 people every half hour there were always a lot of people around the entrance; one tour usually finished five minutes before the next started. With everyone wearing their hard hats a tour is ready to descend into the bunker. Photo Kieren Messenger

Organised Chaos

The narrow pavement in Brook Road became quite busy with visitors arriving, being issued with a hard hat and a wrist band, being introduced to the tour guide and descending the stairs into the bunker. The tour started with a mandatory Health and Safety briefing at the bottom of the stairs (ironically having already passed the main doorway – the lowest head-banging point!).

At more or less the same time visitors who had ended their tour were ascending the stairs, giving up their hard hat and wrist band and departing. There were also visitors who had arrived early, visitors reading the information display boards, and Sub Britters answering visitors' questions.

The scene could be perhaps best described as organised chaos. A number of vehicles (including the Police) regularly passed slowly by, curious as to why there were so many people gathered on the pavement. There were a number of regular passers-by on a number of public open and private open days. On one public tour there were two blind visitors (with their guide dogs) who were apprehensive at first but were each assigned a personal tour guide.

The 'Prime Minister' Winston Churchill attended one of the open days on 9 June 2016. In this posed view he is seen with left - right Maria Michael (Network Homes), Roy Kenneth (senior tour guide), Katy Bajina (Network Homes) and Andrew Smith (senior tour guide)

The Prime Minister puts in an appearance

Winstan (Stan Streather – a professional Winston Churchill look-alike[4]) put in his first of two appearances at Paddock on 9 June 2016. He arrived already in character accompanied by his driver, Michael Gill, who was in the attire of a vicar.

My first reaction after greeting them was confusion. It was obvious Winstan was impersonating Churchill but was Michael a real cleric? It turned out he was in fact Winstan's local vicar. The presence of our great wartime leader enhanced the open day and was greatly appreciated by visitors and helpers alike.

Winstan had obviously studied the life and times of his alter ego and visitors asked a stream of questions. Winstan's answer was sometimes to the effect *"I am over 100 years old. I can't be expected to remember everything."*

Most visitors had an interest in Paddock and were attentive to the words of the tour guide. It was always very pleasing when visitors on public open days expressed (without being prompted) their thanks and said that they had enjoyed their visit.

Our former prime minister enthrals some of the visitors with stories of the 'old days' in the cabinet room even though many of them probably don't know who he was!

This always puzzled me given much of the retrievable metal has been removed and much of the woodwork has succumbed over the years to spectacular dry rot, wet rot and mould growth leaving Paddock a dilapidated and decaying shell of its former self. I can only attribute their enjoyment to a combination of the depth of knowledge and descriptive skills of our tour guides and the fascination in the decaying splendour of a once top-secret site. Our wartime leader's appreciation was shared amongst and gratefully received by the Sub Brit members present.

Visitors often had to wait for their booked tour so display boards were provided (by Bill Ridgeway) to give them something to look at while waiting. We also did a very good business selling copies of our Underground Site Directory. Photo Nick Catford

One feature of Paddock was that it maintained a steady ambient temperature. On cold days it was good to volunteer to accompany a tour in the relatively 'warm' bunker. Conversely on warm days it was pleasant to emerge from a 'cold' Paddock. The weather was mainly kind to us – although there were some drizzly and damp days and one day on which the gazebo was blown down.

Guiding presence

Tour guides had off-script moments which added a bit of humour into the 'history lesson' for the visitors and for Sub Britters who had heard the 'story' so many times. One tour guide well known for having a voice akin to a market trader started tours with something like *"I hope you can all hear me. I'm feeling a little hoarse today."*

Another guide usually indicated the air conditioning ducting by 'accidentally' touching it and sending a shower of water onto unsuspecting visitors.

Sometimes a guide asked for a volunteer to throw a switch in the Standby Generator Room to get the generator going. There was of course consternation that the generator did not fire up – but it was OK given it had not worked for many years. Other volunteers (often children) were asked to stand at the place occupied by Winston Churchill in the Cabinet Room; or to assume the pose of a telephonist seated at an imaginary switchboard in the Telephone Exchange Room.

The volunteer was asked to imagine connecting important calls between Paddock and Whitehall – an alien concept to most youngsters who know the world only heavily populated with mobile phones. The role-play was always taken in good humour – and helped make the tour less (metaphorically at least) dry.

One of many documentaries filmed at Paddock was Disappearing London *presented by Madness frontman Suggs. Suggs is seen with Nick Catford in the generator room.*

During the open days we had a number of visitors who worked at the Post Office Research station and remembered the bunker and what it was used for after the war. We had one elderly lady who worked at the bunker for the short time while it was on standby during the war. She was a telephonist and told us her job was to man one of the switchboards all day. When she arrived in the morning she always got one phone call then nothing for the rest of the day.

The last duty of the day for the Sub Brit teams was to walk around all parts of Paddock to ensure a visitor had not been left behind before locking-up; it could be several months before the next time Paddock was entered. This marked the end of a ten-hour day for many members. Having gone up and down and round and round dozens of times, they went home tired but content in knowing they had entertained, educated and satisfied the curiosity of hundreds of visitors.

While most of the filming at Paddock was documentaries, there were a small number of dramas. The majority of scenes in The Fades *were filmed in the GPO frame room where some props were brought in to depict wartime bric-a-brac. During the filming the scenes were generally dark and this was rarely clearly seen. Photo Nick Catford*

Private open days and filming

On top of the public open days, a number of private tours were arranged over the years. These often took the form of an extended tour, and a look at the remaining surface buildings of the nearby Post Office Research Station. As well as tours for Sub Brit members, others attending have included the London Fire Brigade, members of the Churchill War Rooms (IWM), English Heritage staff and members and many others.

Paddock was used as a filming location on numerous occasions, which Sub Brit members usually attended to help ensure health and safety guidelines were followed. Many of these were documentaries where Sub Brit took a more active role in helping present the site to viewers; a list of some of these is at the end of the article. The site has also featured in a number of dramas such as *Humanity* and an at times very violent BBC3 drama *Fades* where

Paddock played the part of an old WWII bunker. The plot: student Paul is haunted by apocalyptic dreams. He is able to see spirits of the dead, known as the Fades, all around him. The Fades cannot be seen, smelt, heard or touched by other humans - they are what is left of humans who have died but have not been able to ascend, because the ascension points on earth have been closing, and few can go through the ones that are still open. Because of this, the Fades left on Earth have become embittered and vengeful toward the human race, and have since developed a way to become partly human again and regain control of touch within the real world.

Two violent scenes from The Fades, *both take place in the BT frame room. In both Fade Natalie is seen hanging from the BT main distribution frame.*

They remain unseen in the world except to those special few like Paul, called 'Angelics', who have the ability to perceive the Fades. Paul finds himself pulled into a conflict between the Angelics and the Fades, trying to prevent the Fades from regaining physical form and destroying the human race. (Fades description from Wikipedia) *The Fades* starred Iain De Caestecker and Johnny Harris. For the filming of this drama the BBC took over part of Brook Road for almost 10 days with articulated lorries housing BBC equipment and services lining both sides of the road. The 'stars' arrived by limo from their hotel each morning.

The bunker was also used for a number of music videos. Members of The Prodigy visited, they liked the site but decided against using it because they weren't able to drive an ambulance along the main corridor. A grime rap video was completed by the artist Durtty Goodz. His rap video was filmed partly at Paddock and partly at disused parts of Charing Cross tube station on the Northern line.

A more complete list of films is included in the Paddock Information Collection (see below).

Light Detection and Ranging (LIDAR) [5]

LIDAR is a surveying method which measures the distance between the 'camera' and the target by illuminating the target with laser light and measuring the reflected light. The output of the scans together with conventional images are then stitched together to form a 3D representation of the target which, with the appropriate software, enables the viewer to navigate within and between rooms – even apparently going through walls, floors and ceilings.

Two LIDAR scans

Paddock was scanned (internally and externally) over five long days in the period between 2016 and 2018. Corridors and some rooms required multiple scans to record the hard-to-get-at places. Preliminary output of the LIDAR scan is encouraging and on the Sub Brit website.

Visits suspended

Unfortunately Network Homes decided in May 2018 to put all visits to Paddock on hold. Opening the site was not part of the 'core business' of a social housing enterprise and there were both cost and health and safety considerations.

The last public open day was 22 September 2018. This was a disappointment to many Sub Brit members who have loyally supported openings over the years. But we are grateful to Network Homes for their support over the years with both resources and finance.

Talks have been held between members of the Sub Brit

Angry grime rapper Durtty Goodz performs Oi Wot you Lookin At. *Photo Nick Catford*

committee, Network Homes and other parties to try and find a model that would allow visits to continue. For obvious reasons during the present Coronavirus lockdown these discussions are on hold but it is hoped that a solution will be found once they recommence. It is not known whether or not the pumps are still working or if Paddock is continuing its journey into gentle decline.

Appreciation

Thanks to all the volunteers who have been kind enough to share their reminiscences with me and to Maria Michael, ex-Stadium Homes, for all her help over the years. Historic attendance and subsequent enquiries show that demand for visits remain high. Let's all hope that open days will be resumed – one day.

References

[1] Brent Council, Grant of Planning application 97/1409

[2] Brent Council, Grant of Planning application 99/1457

[3] Brent Council, *The Architectural Heritage of Brent* (1984)

[4] https://winstan.co.uk

[5] https://en.wikipedia.org/wiki/Lidar

Further Reading

https://www.subbrit.org.uk/sites/paddock-standby-cabinet-war-room/

The Paddock Information Collection

http://www.bunkers.org.uk/paddock.htm

Dramas and Documentaries (most are online)

Paddock secret underground bunker (BBC) (featuring Mark Russell): https://www.youtube.com/watch?v=CK2Ds_gBsOE

Secrets of underground London (featuring Andrew Smith): https://www.youtube.com/watch?v=B8iLrVKQ8VA (starts at 39 minutes)

Disappearing London (with Suggs) (ITV) (featuring Nick Catford): https://www.youtube.com/watch?v=f0EoZy3dK18&list=PL1vazjYo0VNnlL3G4uQLZ8NHOLUikDhY5&index=13&t=0s

Paddock, WWII Standby Cabinet War Room (2018): https://www.youtube.com/watch?v=GVCsFGzoNBs

Churchill's secret bunker, Codename Paddock (2008) (IKS Production) https://www.youtube.com/watch?v=CiU7KQ-6r6g

Durtty Goodz, 'Oi Wot you Lookin At' A rap video made partly in Paddock https://www.youtube.com/watch?v=-XwyP2fjj-8

Humanity (Martyn Lomax) (March 2009) – A nuclear holocaust survival story https://www.youtube.com/watch?reload=9&v=N3pHK3djkmU)

Open House London promotional film (2016) https://www.youtube.com/watch?v=cKE5UXXx--Q (starts at 7 minutes)

Paddock secret underground bunker (BBC) (Part 1) (featuring Mark Russell) https://www.youtube.com/watch?v=CK2Ds_gBsOE

Paddock secret underground bunker (BBC) (Part 2) (featuring Mark Russell https://www.youtube.com/watch?v=tC4VKt_Mr0o

Secrets & mysteries (October 2014) 5 places to explore underground London (featuring Rob Bell) Episode 2: Churchill's secret war rooms (not available online)

Secrets of underground London (featuring Andrew Smith) https://www.youtube.com/watch?v=B8iLrVKQ8VA (starts at 39 minutes)

The Fades (BBC3) (June 2011) – A supernatural drama horror series in 6 parts. Episode 4 was made partly in Paddock https://www.bbc.co.uk/iplayer/episode/b015v0nh/the-fades-episode-4 Identifying some of the locations in Paddock is challenging.

Hidden Britain by Drone Series 1 Episode 1 with Tony Robinson. Channel 4 10 April 2016 (not available online)

Miners Lamp History from Flame to the 'Safety Lamp' to Electric

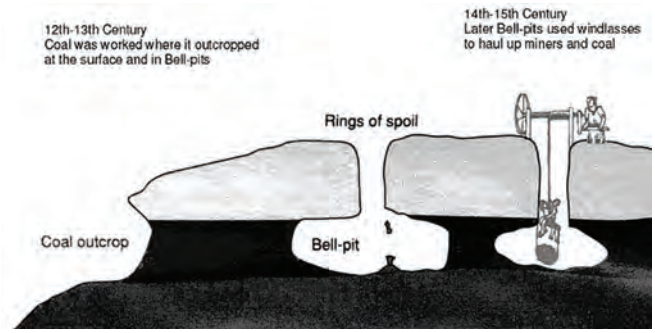
Andrew Watson, Gary Chedgy and Roger Gosling

Partly from Health & Safety International Magazine, reproduced with permission

Providing miners with a safe and yet powerful form of lighting for use in one of the most hazardous environments encountered has taken a long time, effort and initiative.

Introduction

Mining, coal mining in particular, started thousands of years ago. The original method used was to find the outcrop (where the coal surfaced) and follow it, removing the coal as you mined. This developed into bell pits so named because of their shape. Miners would mine straight down until they reached the coal seam. They would then open up the void to remove the coal, thus creating the bell pit. Once out of sight from the surface, this necessitated the use of artificial lighting, initially in the form of naked flames from candles, followed later by oil and carbide lamps to illuminate the works.


12th-13th Century
Coal was worked where it outcropped at the surface and in Bell-pits
14th-15th Century
Later Bell-pits used windlasses to haul up miners and coal
Rings of spoil
Coal outcrop
Bell-pit

Bell pits

The vertical shaft forms the handle of the bell and the void where the coal was removed is the bell itself. As demand for coal increased, the miners realised that the unproductive part of this process was the creation of the shaft. As mining continued to progress bell pits were 'joined' underground by connecting roadways, thus coal was mined further and further from the connections to the surface. While this was fantastic for industry, it created two safety problems. The first and most obvious problem was the need to illuminate the underground work. The second was to provide sufficient fresh air to ventilate the working area.

The solution to the first problem was to increase the use of candles. This allowed the work to continue to develop further from the entrances. Mineworkers were being killed or injured, however, due to the lack of adequate ventilation in the workings both to provide breathable air and to dilute any noxious or explosive mine gases.

The early solution to this was to light a fire at the base of the shaft connected to the surface allowing the hot air to rise within the shaft. Fresh air would then be drawn down other shafts or from surface connections to create an air flow. This was quite successful up to a point but as the need for coal increased, so too did the area of the mine workings. This increased the problem of explosive mine gases collecting, mainly methane, as well as creating oxygen deficient atmospheres in other areas where ventilation was inadequate. The ventilation of coal mines itself has a fascinating history but will not be considered further in this article.

Explosive Mixture

This solved the immediate problem of air and light but created another - explosions and fires. With coal comes methane (CH_4), known to miners as *firedamp*. Methane is explosive between 5 and 15%, - the naked flame providing the ignition source. Beyond 15% there is insufficient oxygen in the atmosphere to support combustion and also to support human life. Oxygen deficiency was known to miners as *blackdamp*. As the percentage of oxygen reduced due to poor or non-existent ventilation, miners noted that the amount of light emitted from their candles or oil lights reduced and eventually the flame extinguished, leaving miners in darkness in an oxygen - deficient atmosphere.

Recorded deaths for a ten-year period between 1870 and 1880 were 2,700 miners (men and boys) losing their lives to explosions alone. The numbers (not recorded) prior to this period would have, if they were available, also been very high.

The Penitent or the Fireman

The early solution was to employ a 'fireman' to enter the mine workings in advance of the miners to test the mine environment. The fireman would cover himself from head to foot in wet sackcloth to protect himself as much as possible. He would then enter the workings and search out accumulations of methane. Methane being lighter than air, it accumulates in the roof of the passages. He

would ignite the pockets of methane with his flame (a candle held up high on a stick), so allowing it to burn prior to the miners entering the workings to produce the coal. If he was lucky, the methane would burn in front of him and he would be safe. If he was unlucky, however, the methane could explode and flash over him; he might survive this due to all the wet clothing he was wearing.

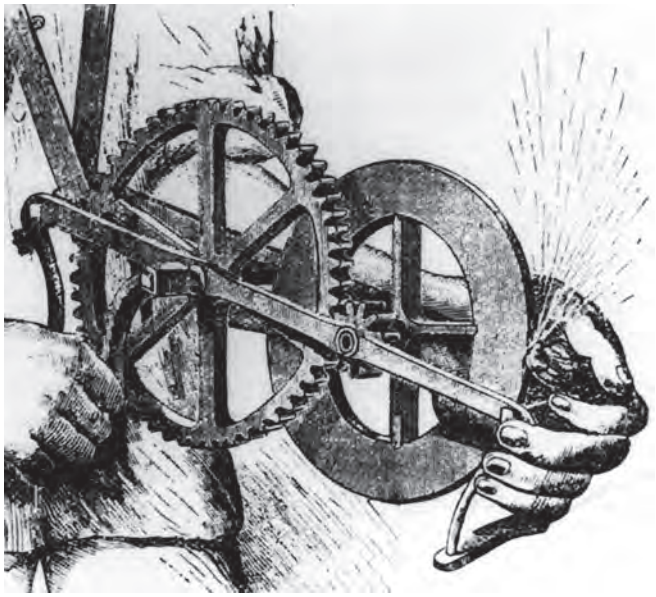
While the use of the fireman may not seem a particularly sensible idea, it was effective up to a point. It reduced the number of miners' lives put at risk and, if the accumulation of methane was low, the fireman survived. Unfortunately, the fireman had, in most cases, no way of knowing how much methane he was igniting other than to estimate how much could accumulate at the roof or in a void. If his assessment was wrong, he could be explode a large volume of methane, possibly with fatal consequences.

This situation could not continue – something had to be done. The challenge went out to the scientific world to come up with a light that could safely be used underground to provide the miners with light without igniting the methane.

Scientists

There was a period where both the weird and the wonderful were tried to solve the problem. Among the weird was the use of dried fish skins. These produced a very ineffective bioluminescence (phosphorescence) to provide light for the miners. Possibly just as weird (and ineffective!) was the use of bottles filled with fireflies.

Carlisle Spedding invented the Spedding flint mill. This consisted of a steel disc, that the miner rotated at high speed, then pressing a flint against the spinning steel disc produced a stream of sparks which other miners would work from. As you can imagine, this method supplied the miner with a minimum of light for a lot of effort – usually provided by a young boy.



Spedding flint mill

It was assumed that the sparks had insufficient energy to ignite methane, however in 1785 there was an explosion at Wallsend Colliery. One miner was killed, but amazingly, the miner who was operating the Spedding Mill survived and provided the evidence that the ignition source for the methane explosion was the Spedding Mill he was operating at the time.

Flame Safety Lamps

During the nineteenth century several inventors turned their minds to the problem of safe lighting in mines. The three most well known involved in this enterprise were Dr William Reid Clanny, Sir Humphrey Davy and George Stephenson.

Clanny

Clanny was the first to invent a reasonably effective oil lamp.

The initial Clanny lamp consisted of an air tight chamber, in which the air required for combustion was pumped by bellows through a water seal. This seal also allowed outgoing gases to cool so no explosion could take place. Clanny, who was an Irish doctor, presented a paper on this invention to the Royal Society in May 1813. For his effort he was awarded a gold medal from the Royal Society of Arts. His later designs evolved to utilise Davy's gauze screen above a glass cylinder which surrounded the flame burner.

Clanny lamp. Photo from Gary Chedgy collection

Davy

In the late summer of 1815, Humphrey Davy was invited by the Sunderland Committee to turn his attention to the problem of safe lighting in mines. He conferred with Dr Clanny, among others, and by October was corresponding that he had discovered during his experiments that if the

holes in a gauze screen placed around the flame were small enough, the mesh would cool the flame, reducing the amount of heat available to such an extent that it would not ignite the methane. He presented the information on his lamp to the Royal Society on 9 November 1815 and carried out trials in Hepburn Colliery in January 1816. He was awarded the Rumford Medal and £2,000 (equivalent to at least £150,000 today) for his efforts.

Stephenson

Later to become a renowned Civil and Mechanical Engineer, George Stephenson did not come from a scientific background. His experiences as an engine man at Killingworth Pit led to his interest and experimentation with firedamp; his first lamp design was tested in October 1815. The lamp encased the flame within a glass cylinder, which was then capped by a metal cover. This cover featured small holes through which the flame could not pass and it was further protected by a metal bonnet to isolate the flame from the methane.

Davy lamp.
Photo from Gary Chedgy collection

This worked and was much more practical for daily use by mine workers. He confidently proved the effectiveness of his lamp at Killingworth Colliery in December 1815 by holding it in front of a methane blower (methane under pressure) with no ignition of the methane.

Stephenson was accused of stealing Davy's invention. Following an inquiry, Stephenson was exonerated and awarded £1,000, but this was never accepted by Davy, even though a House of Commons Committee found that Stephenson had an equal claim to Davy for the invention of the flame safety lamp. All that said, the lamp recognised today is based on the Davy lamp and the name most closely associated with its invention is that of Sir Humphrey Davy.

It was then discovered that the Davy lamp could also be utilised to test for methane and oxygen deficiency in the mine atmosphere. If methane was present in the mine either in accumulations to the rise or in the ventilation general body, the flame of the Davy lamp burned higher with a blue tinge. This detection became incredibly refined; for example, with the lamp burning a small, yellow tipped test flame, it was possible to determine the percentage of methane present in the mine environment. It then became possible to set 'safe limits of methane' for miners to work safely. Some lamps were even equipped with a metal gauge to measure the height of the flame thus giving a percentage of methane present. Mining law was developed to ensure a margin of safety was introduced to protect the miners (remembering that methane is explosive between 5 and 15%; above that the methane has displaced oxygen and prevents ignition).

- At one and a quarter percent methane, electricity was switched off to remove a potential ignition source;
- At two percent methane all miners were removed from the mine.

Museseler

The next two major developments of the safety lamp emerged from Europe. The first was designed by Belgium engineer Mathieu Louis Mueseler in 1840. The lamp design was similar to Clanny's, but added an internal chimney. This aided the air flow inside the lamp, which gave a clearer light than the Clanny lamp. This lamp was hugely successful, particularly in continental Europe.

Two Mueseler lamps. Photo from Gary Chedgy collection

Marsaut

Invented in 1882, by Jean Marsaut, a French mining engineer, this lamp design replaced the internal chimney with a second conical gauze. On later versions a full bonnet surrounded both gauzes. A lot of late nineteenth-century and early twentieth-century lamps used both the work of Marsaut and Mueseler in their designs. Most also incorporated Clanny's design of using a glass around the flame to provide more light. By the time we get to the nationalisation of the coal board in the late forties, the approved design was in fact a bonneted Marsaut lamp. Only three makers were approved by the NCB, these being Thomas & Williams of Aberdare, Wolf of Sheffield and Protector of Eccles. All of these lamps featured the double gauze arrangement with a bonnet. Probably the most successful example was produced by Protector: the GR6S also incorporated a Garforth Gas testing device.

So was the problem solved?

Well not entirely, for two main reasons. While the flame safety lamp could be used safely, it did not provide sufficient illumination for miners to work safely and so produce the amount of coal required. Secondly, if the lamps were not maintained and used correctly, they could still become a possible ignition source for the mine gas – the slightest damage to the gauze would allow the flame to ignite gas. The advantage of being able to sample the mine environment had obvious safety and production advantages. In fact, flame safety lamps, carefully maintained, are still in use in coal mines today.

Oil and Carbide Lamps

In the mid-1800s, the oil-wick cap lamp was in use in Scottish mines. These looked like small kettles. The body of the kettle was filled with oil and a wick was pushed into the spout . Use of these was common in the underground stone mines in the Bath (Somerset) area. Similar lamps were also used outdoors, for example at road works.

Oil Lamp

Peg and ball lamps are a type of simple oil lamp, made of tinplate or brass, with a wick, commonly used around late 1800s to early 1900s. The lamp body is basically two parts, the ball (reservoir) and a tapered part which would be fitted on the top over the wick. The lamp is held on by a strap made of leather or fabric.

Peg and Ball lamps in Frog Lane mine

Hand-held carbide lamp

While this was an improvement on the amount of light produced and was the start of the lamp being attached to the miner's helmet (or soft hat as originally), there were three main disadvantages to oil-wick cap lamps:

- The smell
- The smoke
- They could ignite methane

Carbide lamps were developed in the early 1900s. Otherwise known as an acetylene lamp, this consists of an upper water reservoir from which water is slowly dripped on to calcium carbide in a lower chamber. The chemical reaction produces acetylene gas (C_2H_2) which comes out as a fine jet of gas and is ignited. The rate of flow of the water controls the size and therefore intensity of the flame produced. Originally carbide lamps were used on cars and bicycles and for mining were hand-held.

Later a smaller version was invented which attached to the miner's hat. Lamps like this were still in use in Frog Lane Colliery, Coalpit Heath, when it closed in 1949;

Miners with felt hats in Frog Lane Colliery.
From SGMRG Frog Lane book page 62

Premier carbide cap lamp

note in the photo, one of the miners is smoking. When Roger Gosling started caving in 1960, this was with a Premier carbide lamp and compressed cardboard helmet, as in the picture; this one has an older version of fixing which needed a small hole at the top of the helmet's lamp mounting. Later versions had a flat bracket fixing to a different style mounting as is the case with the later electric cap lamps.

The electric cap lamp

These lamps had to have an intrinsically safe design applied to the electrical equipment and wiring, specifically for hazardous locations such as coal mines. The technique is based on limiting energy, either electrical or thermal, to a level below that required to ignite a specific hazardous atmospheric mixture.

Around the 1880s, Britain, Germany and America were developing battery powered miners' cap lamps. These early lamps were heavy and the illumination produced was poor. Development continued over the next 20 years with little progress. Two major explosions at Whitehaven and Hutton, thought to have been caused by misuse or poor maintenance of flame safety lamps, resulted in 500 miners' lives being lost. A coal owner, Sir Arthur Markham, decided this situation and loss of life was unacceptable and in 1912 he announced a competition with a prize of £600 for the design of a safe lamp for mining. The winner, Herr F Farber invented the Ceag lamp. The first battery powered lamp to receive Home Office approval was the one that finished second in this competition. This was the Oldham Type C electric safety lamp. The batteries in both the Ceag and the Oldham were lead acid cells.

The Mine Worker
who keeps the pace
A MINER works only as fast as his lamp will let him—or, to put it more simply still—light governs output.
Mines lighting has improved immeasurably in the last generation, although there are still many miners who work with lamps that give insufficient illumination. And—when it is appreciated that a lamp can lose up to 40% of its light output without that loss being detected in the lamproom—the whole question clamours for investigation.
Realising that until light could be accurately measured, there would be no means of obtaining a satisfactory answer, Oldhams created their Light Measurement Service. By this simple yet accurate method, it is possible for the exact light-output of any lamp to be determined in the colliery lamproom.
This investigation will be carried out by one of our Technical Representatives and a complete report on your lighting installation supplied, entirely without fee or obligation.
Remember, the lamp sets the pace — and unless you are obtaining the light you pay for you are handicapping your own effort.
OLDHAM
Self Servicing MINERS' CAP LAMPS
OLDHAM & SON LTD · DENTON · MANCHESTER · EST. 1865

From https://www.gracesguide.co.uk/Oldham_and_Son

The Mine Worker who keeps the pace

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Remember the lamp sets the pace – and unless you are obtaining the light you pay for you are handicapping your own effort.

OLDHAM Self Servicing Miners' Cap Lamps. Oldham & Sons Ltd., Denton, Manchester. Est. 1865.

These early electric safety lamps looked, in shape and size, like the original flame safety lamps. These were hung up and provided illumination all around the workplace. Development of these lamps continued and involved reducing the weight and improving the illumination for the miner.

In 1930, the first of the miners' electric cap lamps was designed. This was a giant leap forward allowing the miner to direct the light from his lamp to where he needed it. This was better for production and more importantly offered a vast improvement in safety. The battery was worn on the miner's belt and was connected via a cable to the lamp, which was fitted to his cap. The cable was originally encased in a steel cover to protect it from damage (soon stronger cables were developed not requiring a steel cover). The battery could provide illumination equivalent to that of six candles. It was capable of providing enough power to last 12 hours and would be recharged between shifts. If the lamp was broken or damaged, the electrical connection immediately disconnected so the tungsten filament in the bulb cooled, ensuring it would not be capable of igniting any flammable gas that was present in the environment. So we now had the first intrinsically safe lamp for use in a potentially explosive environment.

Battery Technology

The batteries used in these lamps were originally alkaline (Nickel / Iron or NiFe cells), normally manufactured by CeAg or Edison. One problem with these lamps was that they leaked, injuring the miner. The now nationalised coal industry (National Coal Board) made the decision to remove these batteries and replace them with lead acid cap lamps.

Edison alkaline cap lamp.
From https://electrosparkles.com/edison

Exide lead acid cap lamp

By the end of the 1950s, 700,000 British miners were using lead acid self-service cap lamps (normally manufactured by Oldham or Exide). Self-service meant the miner would use the lamp for his normal working shift and then place it onto a charging rack. When he returned for his next shift his lamp was charged ready for use.

ATEX Certification

ATEX is an abbreviation that derives from the French title of the EU Directive: *Appareils destinés à être utilisés en ATmosphères EXplosibles*. It consists of two European Union regulations designed to ensure the safety of products being used in explosive environments.

- Directive 99/92/EC (also known as 'ATEX 137' or the 'ATEX Workplace Directive') on minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres.
- Directive 94/9/EC (also known as 'ATEX 95' or 'the ATEX Equipment Directive') on the approximation of the laws of Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

Charging racks in the lamp room at Boulby Mine. Photo Nick Catford

The battery for these lamps was worn on a belt around the miner's waist. A cable went under or behind the miner's shoulder and up his back to the rear of his safety helmet. At the helmet the cable was attached to the rear and the lamp itself was attached to the front. These lamps continued to be developed, but the improvements were limited to battery and bulb only. Ex-NCB Oldham cells were used by many cavers (though some still preferred carbide lamps) through from the early 1970s till about the late 1990s when much lighter (in weight) cells came into common usage.

Towards the end of the 1990s, the next big step forward took place. LEDs and lithium-ion battery designs received ATEX (Hazardous Environment) approval. Modern LEDs use much less power and produce much more light, so particularly with huge improvements in battery technology, the cells have become much smaller and much less heavy.

Modern Electric Lighting and Lamps

Modern electric lighting is continuing to improve safety and production in mines. Lights without a separate battery pack have been developed, so-called cordless lights. The improvement these bring to the miners' working environment is obvious. The miner still relies on his, now cordless, cap lamp for safety should the power go off or when he is moving around the mine.

Summary

Providing miners with a safe and yet powerful form of lighting for use in one of the most hazardous environments encountered is a compelling and ongoing story. A lot of miners lost their lives and were injured before and during the development of safe lighting. Countless lives and injuries have now been saved by the time, effort, initiative of individuals and companies, and by the introduction of stricter legislation.

These are now the most common miners' cap lamps in use around the world today

Cordless light

Lockdown Underground in the Past

Robert Hall

Looking down the main flight of steps to the lavatory (containing two, now vandalised WCs); to the left, the radio room with the remains of the bicycle dumped on the partition wall. Photo Tim Wellburn

At this time of COVID-19 related restrictions, it seems opportune to look back at two underground 'lockdowns'. Although separated by three decades, half the globe and extreme differences in climate, these two events were nevertheless intimately connected by the experience of one man.

The first lockdown was in World War II: the so-called **Stay Behind Cave** on the southern end of the summit ridge of the Rock of Gibraltar that was visited by a party from Sub Brit in 2017.

From mid-1940, the British colony of Gibraltar came under increasing threat. Indeed, Admiral Wilhelm Canaris of the German *Abwehr* (Military Intelligence) was in contact with General Franco to obtain Spanish co-operation for Operation Felix – the invasion of Gibraltar by Germany through Spanish territory.

The threat was recognised by the British and Gibraltar became progressively further fortified, with the Rock becoming festooned with searchlights and gun emplacements and honeycombed with underground storage facilities linked by military communication tunnels.

Nevertheless, it was recognised that although a very high price in blood and treasure could be extracted from any invader, Gibraltar could not ultimately withstand a prolonged and heavy attack by a determined enemy. Thoughts therefore turned to how the possible loss of Gibraltar could be mitigated.

Operation Tracer

Although important as an air and naval base to permit a safe route via Malta, Alexandria and the Suez Canal to India and the Far East, Gibraltar also acted as an intelligence-gathering base for shipping movements through the Strait between the Atlantic and the Mediterranean. To maintain that flow of information in the event of the loss of Gibraltar was the objective of Operation Tracer.

In charge of the operation was Rear Admiral John Henry Godfrey of the Naval Intelligence Division of the Admiralty. He is perhaps now best known as the model for the fictional "M" of the James Bond books written by Godfrey's subordinate, Ian Fleming. However, in real life he was a hands-on operator who held the early meetings

to develop Operation Tracer in secrecy at his home in Mayfair. The plan took the shape of a covert underground observation post high on the Rock in which a team of volunteers would wall themselves in for a period of years and keep the Admiralty in London informed of shipping movements by radio.

The chosen location of this observation post was under Lord Airey's Battery and the present-day British Forces 'Spy Glass' site. The tunnels were constructed with great secrecy by engineers who were kept apart from the Gibraltar-based personnel and later returned directly to Britain.

Sub Brit Chairman Tim Wellburn looking into the ante-chamber of Stay Behind Cave from the arcuate sheet-lined tunnel.

The entrance to the cave was disguised by being hidden behind the arched sheet lining of an existing, but largely abandoned, tunnel. If the operation were activated, a trained observation team would enter an antechamber to the post, the arcuate sheeting would be moved back across and the observers would then wall themselves in behind the sheeting using blocks and cement held inside the cave for the purpose.

The main room in Stay Behind Cave. The cork tiles and plastered walls and ceilings were intended to reduce sound transmission to the outside. The drain is in the far right-hand corner.

From the ante-chamber access was gained to the main room of about 45ft by 16ft in size. This was plastered and the floor covered with cork tiles in order to absorb sound. Apart from being the accommodation quarters for the men, the room also contained provisions intended to be sufficient for seven years.

A water tank at the far end held around 45,000 litres of water. This supply could be augmented by natural seepage through the rock; despite being at an altitude of 1,350 ft and near the summit of the Rock, moisture came from rain and the frequent fog with the Levanter wind. A drain into a fissure in the rock enabled sewerage and waste-water disposal.

The stairs up from the main room. The aperture of the eastern observation post is visible at the top. Running up beside the stairs on the right is the square-section ventilation duct, while on the left is the asbestos pipe through which the radio aerial was threaded.

From the main room, a short flight of concrete steps led past rooms containing the radio equipment and the inevitable Elsan toilets. The stairs then continued up to the observation post on the precipitous east side of the Rock facing the Mediterranean. This aperture was just large enough for the men to climb through onto a ledge to get some benefit of sunshine, yet without being easily seen. However, its primary purpose was to observe shipping and other movement from the eastern side of Gibraltar.

Double Aspect Outlook

A short way back down the stairs, a branch off to the left headed up some further stairs to a dog-legged passage and the western observation post for viewing the important port of Algeciras. The slope of the Rock on this side is less steep and more care was needed in determining its location and size for it to remain undetected. The result was a narrow horizontal slot sealed with a wedge when not in use.

The narrow slot of the western observation post can be seen at eye level immediately to the left of Tim Wellburn.

The slot was disguised by being under a ledge in a rock on a steep slope then being used as a gathering-ground for a freshwater supply to the military installations on the ridge.

Clive Penfold of Sub Brit descends the stairs from the eastern observation post. The stairs up to the passage to the western observation post are on the left. At the foot of the stairs are the walls for the radio room (on the left) and Elsan toilets (on the right). The main room lies a little further on.

The intelligence obtained would then be transmitted back to the Admiralty in London by radio at night. The aerial for the radio was, when needed, threaded through an asbestos-based insulating pipe next to the flight of stairs and out of the eastern aperture. Power for the radio was supplied by batteries that were recharged by means of a dynamo driven by a modified bicycle with a leather "chain" to ensure quiet operation.

The bicycle could also power a ventilation fan and, as a side-effect, gave the men some much-needed exercise. A hand-cranked dynamo served as an alternate and back-up.

Construction of the bunker started in late 1941 and continued into 1942. By mid-1942 the facility was essentially complete and provisioned and two teams of volunteer observers selected and trained. The teams alternated between being on call, but only one would have entered the cave in the event of the operation being activated. Ironically, by the time Stay Behind

Remains of the bicycle-powered fan for ventilation on top of the wall of the radio room.

Cave was complete the threat to Gibraltar was lessening considerably.

At a political level, Spain was less likely to risk its neutrality now that the US was in the war. In the Mediterranean, the tide was beginning to change, starting with the reinforcement of the Maltese air defences. Within a year, the whole of North Africa was in Allied control and the invasion of Italy via Sicily was under way.

Graffiti in the tunnel to the western observation post dated February 1942, presumably made by the construction workers. A Major JA Braithwaite was reportedly killed by a detonation of a charge during the construction.

Sub Brit members near the top of the Mediterranean Steps footpath look towards the ledge outside the eastern observation post, roughly 20 metres horizontally from the landing in the centre of the picture. The narrowness and steepness of the ridge at this point is apparent.

By mid-1943 any realistic threat of invasion of Gibraltar had dissipated. In Gibraltar, the provisions placed in Stay Behind Cave were removed and dispersed and the observer teams stood down. An ultimate Gibraltar wartime underground lockdown was averted.

The narrow slot of the western observation post is fractionally left of centre in this picture. During wartime this slope would have been free of vegetation.

Antarctic Winter 1912

The second underground lockdown, by contrast, did actually happen but was neither planned, nor provisioned, with such foresight. Some of the detail of it is given in Apsley Cherry-Garrard's celebrated book, *The Worst Journey in the World: Antarctic 1910–1913*, an account of his experiences as a member of what would turn out to be Captain Scott's last expedition.

Cherry-Garrard could reasonably have titled his book in the plural; *Worst Journeys*, as not only did it include the sledging from the Ross Sea to the South Pole and, oh so nearly back, but also the terrible trek – in which he participated – around Ross Island to Cape Crozier in the middle of the dark, cold and windy Antarctic winter to recover examples of emperor penguin eggs for scientific analysis.

However, these two journeys have been allowed to overshadow a third ordeal covered in the book; one of extreme privation, persistence and psychological pressure, mostly endured underground through an Antarctic winter.

The main motivation for Captain Scott was to be the first to reach the South Pole, but a mere race to reach that goal involving only 97 miles of unexplored distance to add to Shackleton's existing route was deemed somewhat unseemly and insufficient to gain the official support and necessary finance for the expedition.

Substantial new discoveries, both geographical and scientific were required. One answer to this was provided by a detached group of six men forming the so-called 'Eastern Party'. This turned out to be a misnomer in practice as they ended up exploring the north and west side of the Ross Sea due to the practical impossibility of making a landing to the east of the Ross Sea.

Having over-wintered at Cape Adare at the northwestern extremity of the Ross Sea, the Eastern Party was picked up by the expedition ship *Terra Nova* while making its way back south, having been refuelled and resupplied in New Zealand. On 9 January 1912 they were landed on the west coast of the Ross Sea at what was to become bitterly known as Inexpressible Island.

They were given five and a half weeks to conduct geological, scientific and geographical surveys before they would be picked back up by *Terra Nova* at the height of the short Antarctic summer in mid-February. Although they were not to know it, this covered the time that their leader, Captain Scott, was to reach the South Pole and commence his return.

A pair of Antarctic skuas glide over the rocky surface of Inexpressible Island. Murray Levick, whose boots were falling apart, was to say that: "The road to hell might be paved with good intentions, but it seemed probable that hell itself would be paved something after the style of Inexpressible Island."

A Missed Rendezvous

By mid-February, the Eastern Party was back at the appointed place awaiting *Terra Nova*. The weather had been intermittently harsh, but the sea was clear of the feared pack ice as far as they could see to the east. On board ship, however, the view was very different: thick pack ice had been driven off the coast by continuous strong katabatic winds rushing down the glaciers around Inexpressible Island.

Try as it might, the *Terra Nova* could not get through this icy barrier, perhaps some 30 miles offshore. With modern satellite observations, this is a recognised hazard of access into what is now known as Terra Nova Bay and

the Zucchelli Italian permanent research station. Back in 1912, however, this was not known and nor was there any form of communication available between the Eastern Party and *Terra Nova*. After some time, the ship was forced to withdraw unseen and ultimately leave the Ross Sea heading for New Zealand for the winter.

On Inexpressible Island, the situation was becoming desperate. The sea there remained clear of ice and the weather was tolerable, yet *Terra Nova* had not even been seen. Gradually, the possibility that the ship had sunk became a realistic explanation.

If so, then it was probable that no one in the outside world would even know where the Eastern Party was and given it was an unexplored and unknown location, the possibility of relief would then be negligible; self-rescue would be needed. Adding to the pressure was the pending onset of the long dark, cold and stormy Antarctic winter.

Their initial landing from *Terra Nova* had been rushed and relatively limited provisions had been put ashore for what had only been intended to be a short stay. In addition, the tents they had were barely adequate for the Antarctic summer and were already being shredded by the wind. Food, fuel and shelter would be critical if they were to survive the weather.

Even if they could get through the winter there remained the obstacle of making it back to the expedition base at Cape Evans on Ross Island, some 200 miles away across the Ross Sea. This could only realistically be achieved early in the Antarctic spring, when some daylight was available, but the sea ice remained intact. The alternative of trekking the shore of the Ross Sea, around its many inlets, wide glaciers and high mountain ranges was too long and hazardous – not helped by the fact that it was still largely *terra incognita*.

Descent Accommodation

The men therefore set about excavating a cave in a large snowdrift. It was accessed by steps cut in ice descending some six feet. This led to about 20 ft of passage with small rooms on each side to hold the available stores and serve as a galley – naval terms were used, as five of the six men were serving in the Royal Navy.

At the far end were the living quarters, with just sufficient room for the six reindeer-hide sleeping bags to lie together; the three officers on one side and the three men on the other, as military hierarchy dictated. Doorways were reinforced by biscuit boxes and had doors of sacking, seal hide or tent material to reduce draught, although this gave rise to a real risk of asphyxiation. The maximum height of the structure was around 5 ft 6 inches.

This was going to be home for over six months from 18 March to the end of September 1912. The other important activity was collecting and butchering the available Adelie penguins and Weddell seals before they left the shores for the winter. They were critical; not just as a food supply, but also for their blubber to provide fuel and light.

Oil lanterns were improvised from Oxo tins with wicks of frayed rope dipping into oil produced from molten blubber. Although giving a fair light and some heat, the soot was to leave every surface blackened and greasy and smelling of burnt blubber. Clothes and sleeping bags became coated in it, causing the loss of much of their insulating properties.

Despite the stocks of penguin and seal, food was to be a constant problem. Conventional stores of hard biscuits, cocoa and sugar had to be strictly rationed, especially as portable stores were to be at a premium if they were to have to sledge across the ice after the winter. The diet of insufficiently cooked meat with inevitably poor hygiene conditions led to ptomaine poisoning and almost constant difficulties of stomach cramps and dysentery.

In the best of circumstances this would be an uncomfortable inconvenience; in an Antarctic winter with a 200-mile sledging expedition to follow, it was life-threatening.

The author at the site of the snow cave on Inexpressible Island. Although the snow cave itself has now ablated away, the site is littered with the remains of occupation – possibly including the bamboo sticks shown here. The notice was placed by the New Zealand Antarctic Research Programme in 1969 and reads: "In the winter of 1912, Campbell, Priestley, Levick, Abbott, Browning & Dickason were forced to snow cave on this site when HMS Terra Nova *failed to pick them up."*

Tensions and Release

Prolonged existence in such cramped and austere conditions inevitably led to tensions between the men. Any private disputes instantly became public. From the heavily soot- and blubber-coated diaries of the men it is apparent that the strictures of Royal Navy discipline held under the strain, even to the extent of generating sealed written incident records and formal warnings. The leader, Lieutenant Victor Campbell, comes across as a something of a martinet, albeit largely with good underlying intentions.

Finally, at the end of September 1912 they were able to set out for the expedition base on Ross Island. It took some six weeks of sledging over sea ice and the Drygalski glacier tongue to get there.

As was the case with Captain Scott, their sledges were weighed down not just by the essentials of living, but

A Weddell seal basks in the sun on Inexpressible Island – a century earlier this would have provided food and fuel for the cave lamps.

also geological specimens that included fossils of tropical trees: early evidence of dramatic changes in climate and continental drift. Even on finally reaching the expedition huts at Hut Point and then the Cape Evans base, relief was not immediate, for their colleagues were elsewhere on the route to the South Pole searching for traces of Captain Scott and his companions.

Mount Erebus, the active volcano above the expedition base at Cape Evans on Ross Island could be seen from 150 miles away in the clear air.

George Murray Levick

The link between these two 'lockdowns' is George Murray Levick, RN (1876–1956), the medical officer of the Eastern Party. Normally going under the name of Murray, or 'the Old Sport', 'Toffers', 'Tofferino', or even occasionally 'Mother', he returned to the Royal Navy after his experience on Inexpressible Island, served at Gallipoli in WWI and reached the rank of Surgeon Commander.

In his retirement he founded in 1932 what has become the British Exploring Society and took parties of schoolchildren on expeditions to Finland and Newfoundland, while also pioneering the training of blind people in physiotherapy.

In 1940, at the beginning of World War II, he came out of retirement at the advanced age of 64 to train guerrilla warfare commandos in survival skills at a secret base at Lochailort near Fort William. With his background he was an obvious person for the Director of Naval Intelligence to consult on the supply and manning of Stay Behind Cave.

It seems to be no coincidence that the observation teams for Operation Tracer were to consist of six men – the same number as the Eastern Party in their snow cave. In reality, Murray Levick was more than just consulted; he recruited at least two of the medically qualified observers and lived with the teams through their training, although he probably regretted that this took place on Romney Marsh rather than in Scotland as he had suggested. However, his main role was to consult on the issues of health, psychology and diet.

It is safe to assume that Murray Levick would have placed much emphasis on food supplies. He himself tended towards the fuller frame suitable for the rugby forward that he once was and he had been much affected by food cravings during the winter in the snow cave. There are accounts of him dreaming of walking past lines of sweet and cake shops, but being frustrated at finding them all closed.

Attention was also paid to the needs of recreation: both individual and in a group. The sing-songs of the snow cave alternating between the "popular" and "divine", attenuated as they were by Victor Campbell's limited repertoire of hymns, were not suitable for the clandestine nature of the Stay Behind Cave, but perhaps the giving of lectures and the reading aloud from books might have been able to be carried across.

The psychological importance of routine, the carrying out of maintenance activities and the allocation of responsibilities were lessons well learnt. Inevitably, issues of health took much attention. Infectious diseases were a minor risk to such a self-contained population, but unusual precautions were needed. As with many expeditions, appendices and tonsils were to be removed in advance and if all else failed, provisions were made for the efficient disposal of bodies.

During the Antarctic expedition, Murray Levick learnt many new skills, notably photography, and he wrote papers on his zoological observations. Nevertheless, he failed to master even relatively straightforward navigation and was occasionally prone to mislaying objects.

It was perhaps this characteristic that led Lieutenant Wilfred Bruce, Captain Scott's brother-in-law, to record in his diary that Levick was: "the slowest man I've ever met, but persistent…". Wilfred Bruce's standards must have been high; the bare bones of Murray Levick's life seem more than sufficient for many of us to aspire to being a bit 'slow'.

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Photos by Robert Hall unless stated.

The ante-chamber to Stay Behind Cave. On the left are stacks of bricks and blocks on top of now solidified bags of cement and lime. The bricks, blocks and cement were to enable the observation team to wall themselves in for up to seven years. The lime was to be used to speed up an odourless decomposition of any bodies in the event of deaths of one or more of the team.

An unimplemented 1986 proposal for a new deep limestone mine in Kent

Paul W. Sowan

The County of Kent has had, as has every English county (including former Middlesex), a mining history in which economically valuable minerals have been worked underground. Kent's numerous 'deneholes' throughout much of the Chalk outcrop are now interpreted as Medieval agricultural chalk mines. And chalk was mined in more extensive 'pillar-and-stall' workings at numerous places in north Kent, extending into parts of what is now Greater London such as Chislehurst (the so-called 'Chislehurst caves'). The last of these newer mines, many of which were below brickfields and yielded chalk for addition to the brickearth or brick-clay feedstock for brick-making, were worked into the 1920s.

On a much smaller scale, silver sand was mined in the 19th century at Hollingbourne, and lignite (poor quality coal) from Tertiary beds at shallow depth near Cobham as recently as 1953. Building-stone was quarried underground from the Kentish Rag beds of the Lower Greensand near Maidstone and at Westerham, so far as can be told in the 19th century, and somewhat earlier fullers' earth was mined near the former place.

Kent mining entered upon a greatly enlarged scale in and after 1906 as a result of the discovery in 1890 of deeply buried Coal Measures at a depth of 1,100 feet at Shakespeare Cliff near Dover (at the site of the abandoned 1880s Channel Tunnel trial boring). The so-called 'Dover colliery' shaft reportedly used more coal in its sinking than was ever raised from the seams detected, which were never commercially worked. A 20th century proposal to mine high quality iron ore from Jurassic strata from a less deep level in the Dover shaft was similarly unproductive.

After numerous trial borings and shaft-sinkings throughout east Kent, four producing mines were ultimately developed. Tilmanstone colliery opened in 1906, and was worked for the next 80 years. Snowdown worked from 1908 to 1987, Chislet from 1914 to 1969, and Betteshanger from 1924. Your scribe was fortunate in visiting Chislet once and Betteshanger collieries twice when they were still in production.

In 1986, the year Tilmanstone colliery closed leaving only two deep mines at work. Kent County Council considered, but did not adopt, a proposal to mine Carboniferous Limestone from beds older than, and stratigraphically below the Coal Measures. Kent's demand for roadstone and aggregate for concrete manufacture were then, and still are, largely met from opencast quarries at the Mendip Hills in Somerset. It was proposed that the saving in rail freight costs from this distant source might outweigh the costs of deep mining, even allowing for problems expected from groundwater and coalbed methane.

Limestone of the required quality had been proved in twenty deep boreholes in an area within the Canterbury – Ramsgate – Folkestone triangle, but too deep to be economically winnable below the greater part of the coalfield, where three of the four producing collieries were located. The most favourably located and less deeply buried stone was proved near the Chislet colliery which had unfortunately been closed in 1969 and the shafts backfilled.

Deepening the existing Chislet shafts to reach and work the limestone might have been economically viable, had they remained open. The alternative was to drive a long inclined drift, or sloping tunnel, to reach the limestone at depth below Chislet (about four miles east of Canterbury) at a depth of over 1,100 feet. Presumably the cost calculations resulted in this proposal not being taken forward, as no deep limestone mines resulted.

SOURCE: KENT COUNTY COUNCIL, 1986, *Deep-mined limestone in Kent - a potential source of construction aggregate*. Kent County Council: [48] + 16pp.

Radar Research at Great Malvern – the H Building

Keith Ward

The H building with the Bison Building behind

Many Sub Brit members will be familiar with the ROTOR programme – a massive infrastructure project to build a state-of-the-art radar network during the early years of the Cold War.

One ROTOR site was very unusual in being above ground with no attempt at concealment or protection. This was at the research and test centre in Great Malvern, Worcestershire.

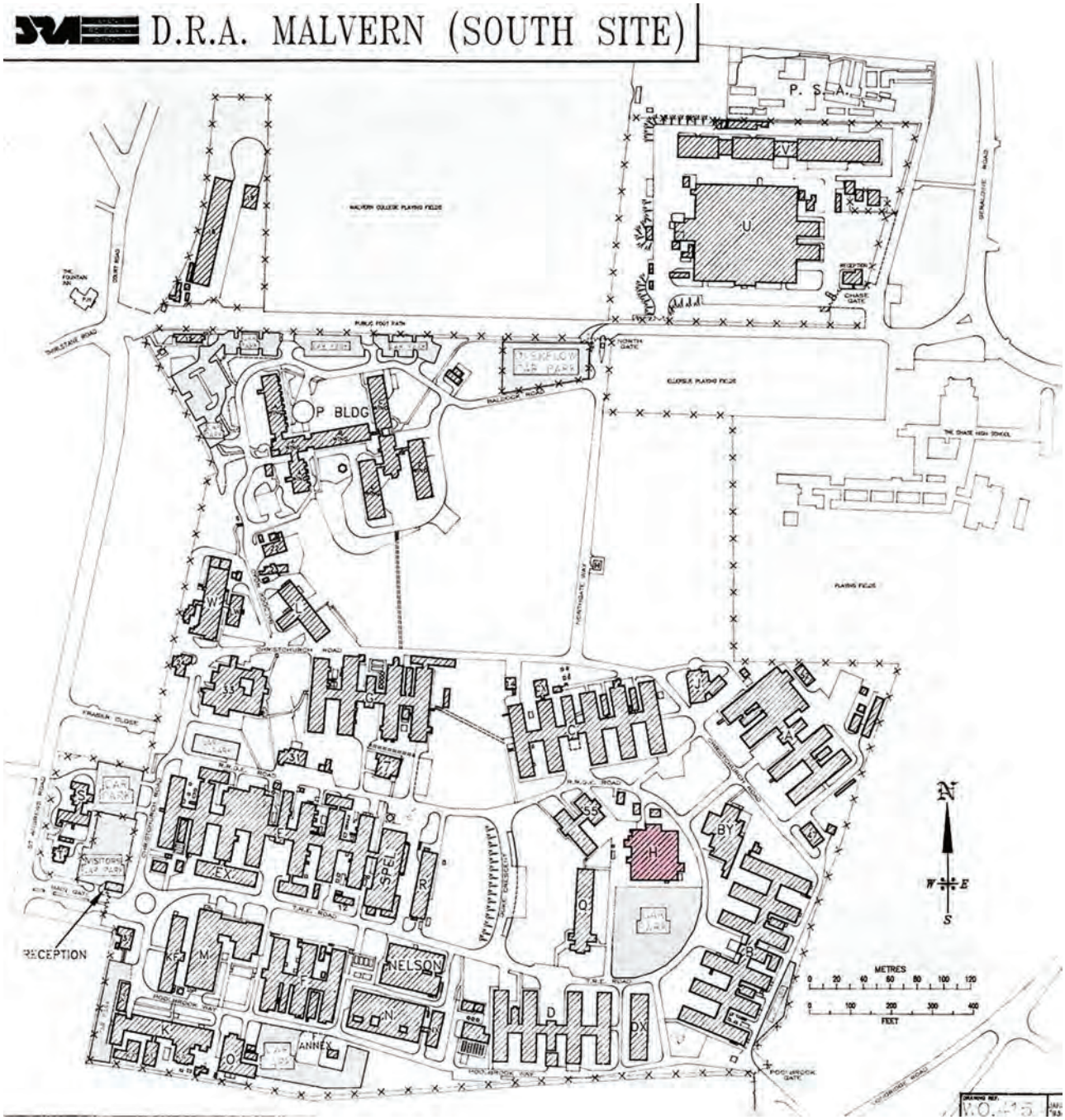
A moving target

Before World War II, radar research started in Orford Ness in Suffolk but moved to Bawdsey Manor near Felixstowe in 1936 and became the BRS (Bawdsey Research Station) when the former site was used as a bombing range. On the outbreak of war in 1939 the research unit moved north to Dundee in Scotland to avoid German raids and later (briefly) to Worth Matravers in Dorset as Dundee was felt to be too far from RAF colleagues and other parties.

Here it was renamed the Telecommunications Research Establishment (TRE) and remained in Dorset until the end of May 1942. Its next move, at short notice, was to Malvern where it stayed for the rest of its history.

H Building

In 1953 there was another name change to the Radar Research Establishment when the Air Ministry and British Army radar research groups merged. After a visit by Queen Elizabeth in 1957 it became the Royal Radar Establishment. Luckily the abbreviation of RRE could still be used!



Malvern Control Room in 1954 as built. The bottom level was later floored over

RAF research was centred on the south site at Great Malvern and it was here that ROTOR was developed. Much of the research on site was classified right up until closure in 2008 and we will limit this article to operational RAF radar – just a small part of the massive research history.

Replica ROTOR SOC

The H Building was specially built for the ROTOR project between 1952 and 1953. The H in its title derives from the alphabetic numbering of buildings on site, rather than from its plan shape (unlike H Block at HM Prison Maze, which was indeed H-shaped).

In 1954 it was fitted out as an R4 Sector Operations Centre (SOC). This was based on RAF Bawburgh west of Norwich but similar to Kelvedon Hatch or Barnton Quarry. The R4 design includes a three-level gallery and the installation included live radar plotters and tote board just like the front-line sites.

The Bison Building with the Giraffe House to the rear

The Bison Building. Photo Keith Ward

Later on, the Bison Building was built which had a two-thirds-scale type 80 radar on its roof which could be linked in with the plotters in H Building. From 1957 the first floor of the ROTOR Operations Room was floored over and development started on automatic tracking and data communications testing for the MRS (master radar station) concept of direct plotting and reporting at each radar station without the need for a separate SOC. With the ground floor covered over it now formed a two-level gallery.

The Giraffe House

During the 1960s and 70s development work started on the joint civil/military radar and control system known as Linesman/Mediator. This was first implemented in 1971 in the L1 control centre at RAF West Drayton. Development included the first-ever touch screen – one of many ground-breaking innovations developed on site.

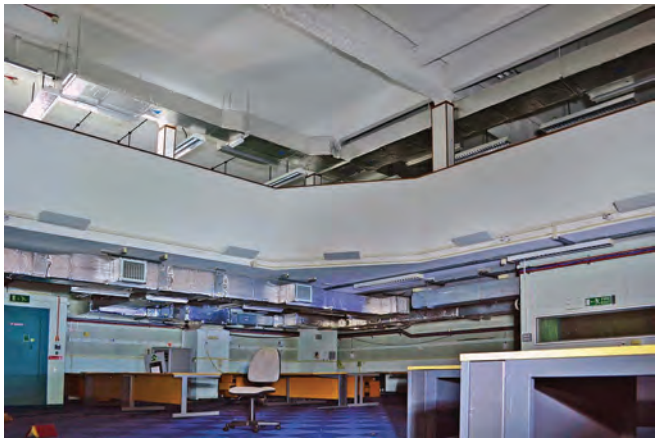
At this time a building nicknamed Giraffe House (as it had a high doorway) was built and this included a complete replica GCI (Ground Control Intercept) operational radar.

Closure and recording

From 1980 new research took place, particularly into electronic warfare, which was based in a new purpose-built building and the H Building became little used. In 1990 the H Building was repurposed as a secure classified research facility with its lower floor becoming a Faraday cage with individual research cubicles.

In 1991 the unit was rebranded and partially privatised as the Defence Evaluation and Research Agency (DERA), subsequently renamed Qinetiq. H Building continued in use until 2008 when it became surplus to requirements.

This is a very brief review of the situation as there were many departments doing ground-breaking research across the wider site. The north site closed in 2003 and was sold for housing; however Qinetiq built a new facility next to the south site that still remains in use.



Galleries in the H building in 2012

Galleries in the H building in 2012.
The tote board was on the left

Present time

2010 saw the formation of Malvern Radar and Technology History Society (MRATHS); this was largely formed from ex-employees who wanted to ensure the unique history of the site wasn't lost. They proposed creating a heritage centre in H Building; however Qinetiq sold the

site to developers and an application for listed building protection was turned down by Historic England on the grounds that the building had been altered a lot since construction.

The developers were very uncooperative. However both the district and county councils are now developing part of site as a business park and the HQ building will house a MRATHS heritage centre – the rest will become housing. The developers removed security from the site and as a result trespass increased with heavy vandalism in 2019, particularly in H Building where computers and furniture were sadly smashed.

Fortunately MRATHS were able to produce a 3D and photographic survey of H Building; however planning permission was granted in October 2019 and demolition is now underway to remove forever the physical structures where so much vital research took place. Much of the work done in recent years and in H Building is still classified under the Official Secrets Act.

The H Building and all adjoining buildings featured in this article were finally demolished in early June 2020. A second attempt to list it was acknowledged but Historic England were unable to follow it up due to the pandemic.

However MRATHS are preparing a book on the history of the site which will hopefully be released later in 2020. Many of the members have some superb stories to tell of the site and the personalities who worked there.

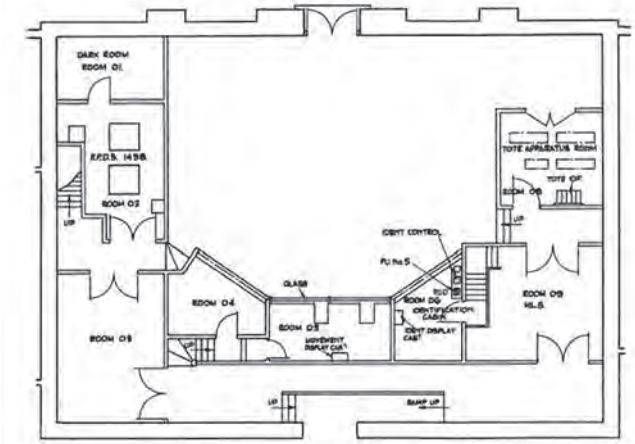
WWII admin block. This remained in use until closure

Appreciation

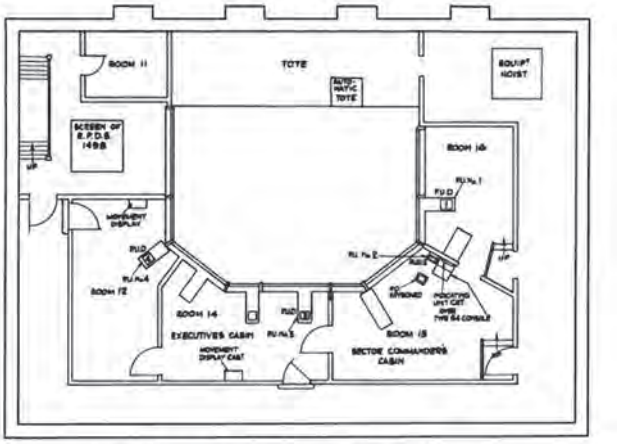
I am indebted to MRATHS members for information and a site tour, particularly to Mike Burstow; also to Martyn Jones who kindly let me use his superb drone aerial views and photos of the Operations Room within H Building. Finally to Ryan White for his help.

Another sad loss to our defence heritage but at least it has been well photographed and MRATHS are committed to ensuring its work isn't forgotten. The MRATHS.org.uk website is recommended for finding out more about this remarkable site and its history.

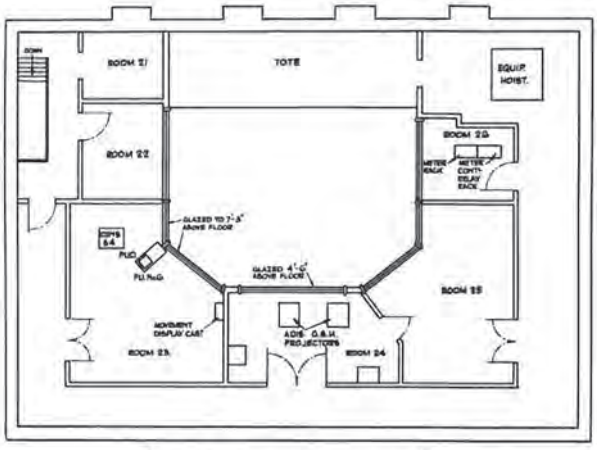
Photos by Martyn Jones



Bunker - Ground floor - 1954



Bunker - First floor - 1954



Bunker - Second floor - 1954

Underground Plotting Rooms, Robben Island, South Africa

William A Martinson

Entrance shaft with pair of hinged hatches, a trapdoor and two steel plate air ventilators

Robben Island, located seven kilometres off Cape Town in South Africa, is best known as the location of the maximum security prison where Nelson Mandela was imprisoned for eighteen years. But during World War II it was home to a substantial set of military infrastructure designed to protect Table Bay and the approaches to its important harbour at Cape Town.

This includes two coastal artillery batteries: the Robben Island Battery (now renamed the De Waal Battery) comprising three 9.2-inch guns, and the Cornelia Battery comprising two 6-inch guns (although both have been removed). The associated support structures to both gun batteries survive substantially intact.

Robben Island is now a World Heritage Site and as such the whole island enjoys a high level of protection. The architectural firm of Osmond Lange Architects was appointed in 2018 by the Robben Island Museum to compile a Built Environment Conservation Manual, encompassing all the structures on Robben Island. This involved the inspection of each building and the preparation of documentation to facilitate their long-term conservation.

Introduction

The underground Plotting Rooms co-ordinated the fire control system of the island's two artillery batteries. They received data on the position of hostile ships and their planned course. This arrived via underground cables from the Battery Observation Posts (BOPs) and the Fortress Observation Posts (FOPs), both on Robben Island and on the mainland.

The information would be sent via the Battery Plotting Room Switch to the receivers in the Fire Direction Table in the Plotting Rooms. The Plotting Room operators then determined and transmitted – again via the Battery Plotting Room Switch – to each of the batteries, the range and bearing that the guns would have to fire.

ASWAAS Rangetakers on watch in the plotting room in WWII.

Of particular interest is that the Plotting Rooms were largely staffed in WWII by members of the Artillery Specialist Women's Auxiliary Army Service (ASWAAS).

The walls, floors and ceilings of the underground spaces are all remarkably well preserved with limited water penetration and the absence of associated moisture damage. This suggests that the structure was well constructed and protected from water ingress.

Architectural Description

The underground Plotting Room comprises a rectangular robustly constructed concrete bunker, sub-divided into four separate interconnected spaces with a stepped access shaft. A separate escape shaft was provided as an emergency escape route. The tops of both entrance and escape shafts project above ground level and each shaft had a pair of air ventilators made from plate steel.

All four of the air ventilators have a square base with a transition piece terminating in a circular pipe at the top. The air-intake ventilators are shorter than the exhaust ventilators. The circular pipe of each ventilator was in turn capped with a heavy steel circular cap. Pipes were covered with a fine steel mesh to prevent the ingress of birds and insects.

A feature of the construction method used for the bunker is that the 'witness marks' of the original timber shuttering planks are clearly visible on the faces of the concrete. Chamfered corners, a typical detail for in-situ concrete work, were generally used at external corners.

Stepped Access Shaft

Entry into the bunker was via a square, hinged metal trapdoor set into the northern side of a pair of steel covers at the top of the access shaft. The two steel plate covers were seated on a perimeter steel plate forming an up-stand mounted on the inner top edge of the shaft. The trapdoor provided for easy personnel access while the larger cover plates could be lifted to provide access for equipment.

This unusual stepped shaft was presumably so designed to minimise the distance in the case of an accidental fall down the shaft, although it would have made it more difficult to lower heavy equipment down into the bunker.

A simple removable pipe balustrade was fixed to the sides of the shaft using robust brackets made of steel plate. This protected the perimeter of the shaft in case the two steel covers were removed. The balustrade was lowered and returned on either side of the trapdoor to facilitate access.

A vertical steel ladder was originally fixed into the side of the shaft. The ladder comprised two heavy flat bar vertical stringers with rungs of solid round bar; it gave access to the upper landing of the shaft. The ladder has since been removed but the 'witness marks' of the curved returns of the stringers are still visible.

Entrance into underground plotting rooms

Intermediate landing

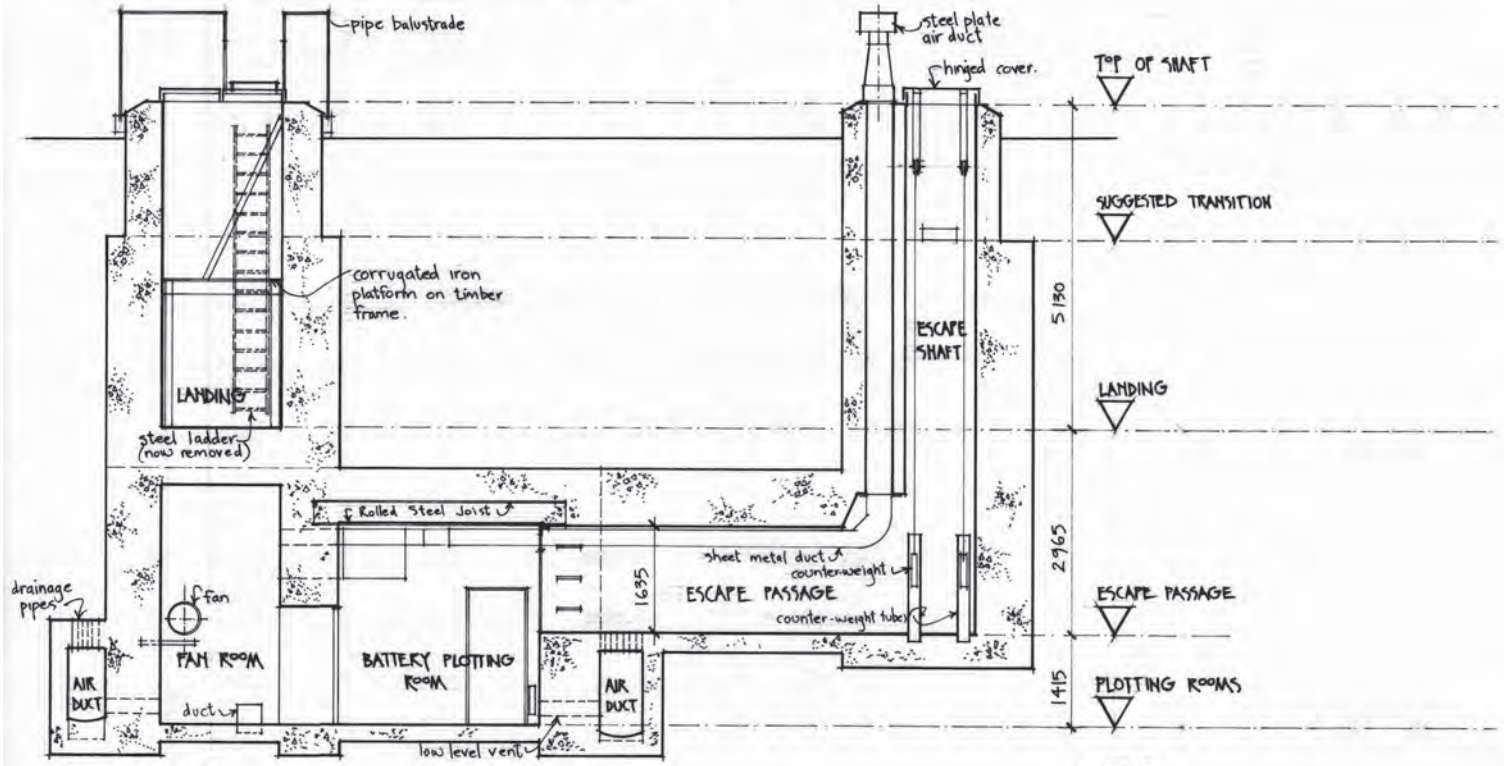
A makeshift intermediate platform of corrugated iron on a timber frame has however been installed into the shaft – above the first landing – onto which one descends via an informal timber ladder, then through a square opening onto a second timber ladder – at right angles to the first – to arrive at the upper landing. This upper landing forms the concrete roof of the Fan Room directly below.

The ceiling of the lower portion of the shaft accommodated a pair of air vents, one of which is open and visible as a square aperture in the concrete soffit. The other opening is concealed by a sheet metal duct. Both apertures continue up to ground level as independent square shafts within a single concrete structure. The open aperture was a fresh air intake and the other was connected to a mechanically vented ducted system, extracting stale air from the lower level spaces.

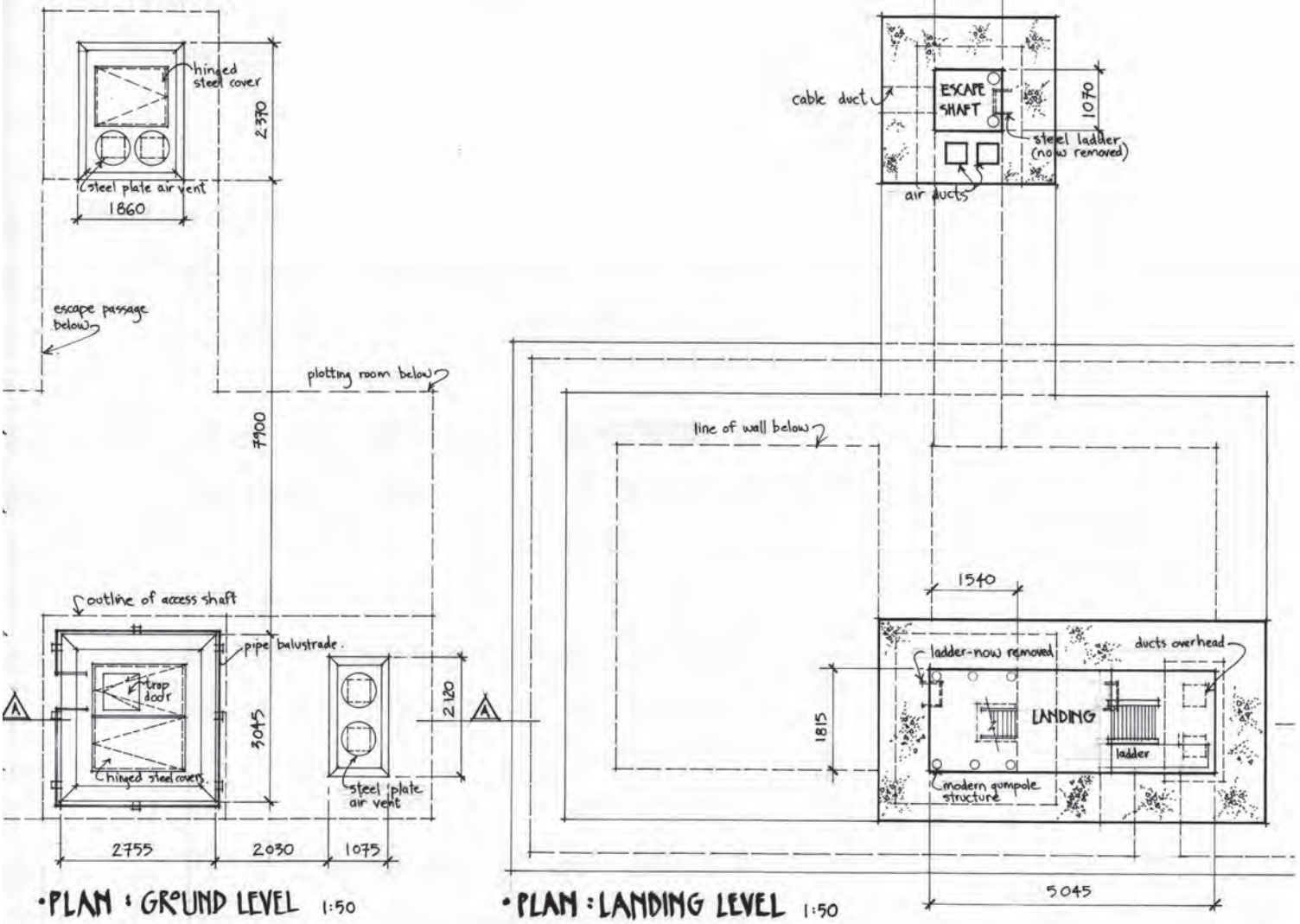
A matching – albeit longer – wall-mounted steel ladder originally gave access from the upper landing down to the bottom landing of the shaft. This steel ladder has also been removed, with the same witness marks remaining.

UNDERGROUND PLOTTING ROOMS. ROBBEN ISLAND.

MEMS. & DELT : W. MARTINSON - OSMOND LANGE 2019.
IN CONSULTATION WITH CHRIS DOONER.



• SECTION B-B 1:50



• PLAN : GROUND LEVEL 1:50

• PLAN : LANDING LEVEL 1:50

However a steep, robustly constructed, timber ladder has been installed in its stead. This has two heavy timber stringers, thick timber treads (carefully let into the stringers) and a simple pipe balustrade.

Base of steep ladder stair within the entrance shaft

Base of ladder stair

The floor level of the bottom landing is 6 inches (150 mm) below the floor level of the Plotting Room. The bottom landing gave access into a perimeter service corridor and into the Battery Plotting Room.

Service and Ventilation Duct

A small service and ventilation duct ran around the entire perimeter of the underground Plotting Room and was accessed from the bottom of the access shaft. Entrance into the duct for inspection and cleaning was through a low rectangular opening. A second smaller square aperture – at the end point of the service duct – opened into the stepped shaft directly adjacent to the entrance.

The duct allowed the movement of fresh air as well as providing a route for electrical cables between the different adjoining rooms. The flat concrete roof of the service duct was penetrated at intervals by sets of three narrow concrete pipes cast into the concrete roof structure. The upper openings of these pipes were overlaid with a layer of broken stones which formed an 'agricultural drain' and allowed any accumulated ground-water to drain into the duct.

The service duct had a gently dished floor which sloped gradually from the end point down to its lowest point. The dished floor terminated in a square sump in the floor at the entrance to the service corridor. A semi-circular floor drain was recessed into the floor of the stepped shaft and also drained to the sump.

Battery Plotting Room

Entry into the Battery Plotting Room from the bottom landing of the stepped shaft was controlled with a heavy steel plate door, rivetted to an angle-iron frame set in a 3 ft (914 mm) thick concrete wall. The door was provided

Steel entrance door into battery plotting room (seen from within the room)

with six heavy duty rotating catches, all with double-sided handles to enable operation from either side. A horizontal sliding panel set into the door allowed views through the door. The sliding panel could be secured in a closed position from within the room.

Galvanised sheet metal ducting for return air in battery plotting room

Sheet metal ducts in plotting room

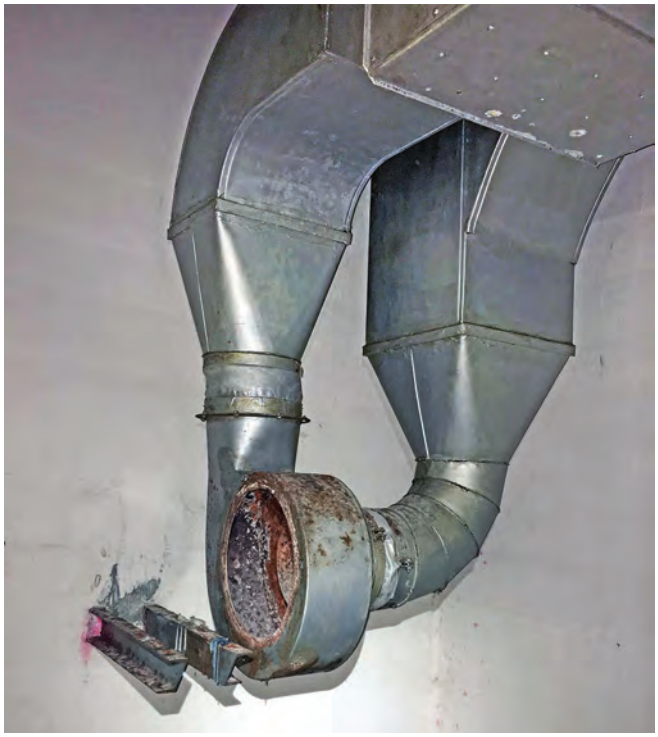
A sheet metal duct mounted to the underside of the Plotting Room ceiling served to extract stale air. Fresh air intakes – from the perimeter service corridor – were located at low level around the sides of the room, some of which intakes were controlled with a moveable louvred panel. The ceiling was formed with rolled steel joists (RSJ) set at close centres with permanent shutters supported between the adjacent bottom flanges. The RSJs were cast into the concrete and formed both the steel reinforcement of the roof slab and the underside of the ceiling.

Battery plotting room showing door into fan room

The Battery Plotting Room in turn gave access to the Fan Room, the Fortress Plotting Room and the emergency escape route.

Fan Room

The Fan Room was accessed via another heavy steel plate door – with a reduced width and head height – through a 3 ft (914 mm) thick concrete wall. An electric motor, mounted on a pair of steel C-channels fixed into the wall, originally provided the motive power for the extractor fan; the fan motor has however been removed.



Galvanised sheet metal ducting for return air in fan room

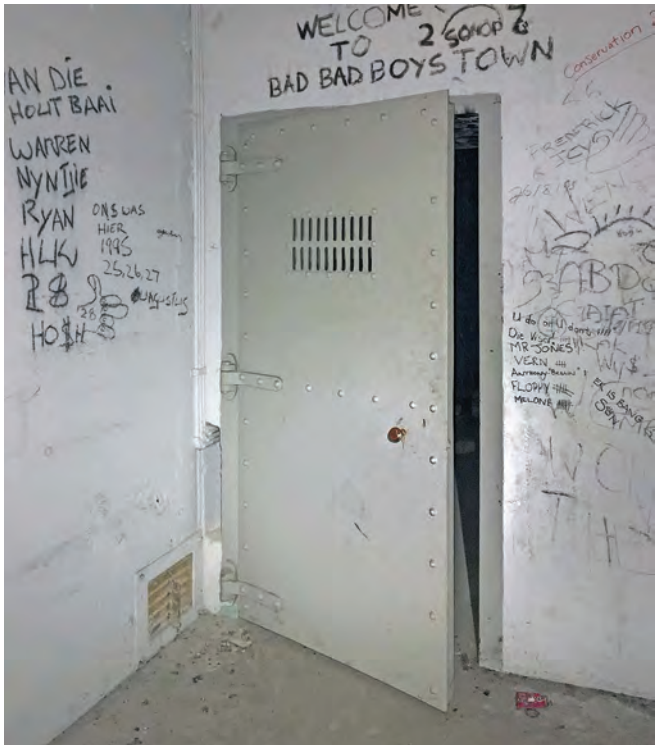
One duct took stale air from the Fortress Plotting Room; another extracted stale air from the Battery Plotting Room. These two joined together before the fan, then split after the fan, with one duct exiting through the entrance shaft and the other duct exiting via the escape route.

The switchgear controlling the electrical equipment was located in the fan room

Both the stale air ducts exhausted at ground level via the steel plate ventilators with circular caps. Adjacent to each exhaust ventilator was a shorter, similarly detailed fresh air intake.

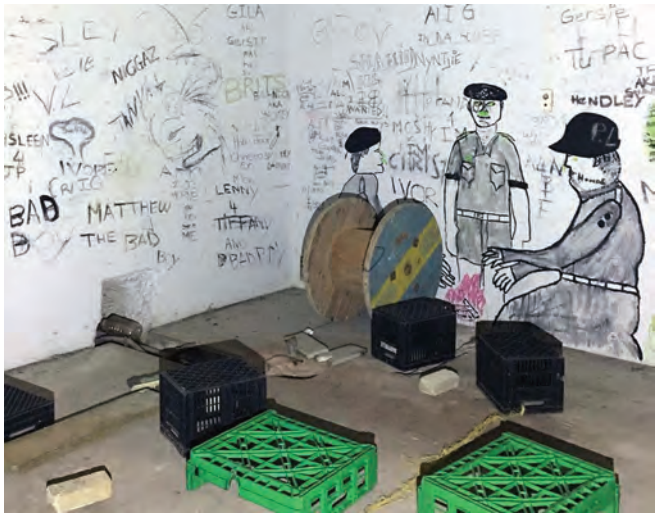
Fortress Plotting Room

The Fortress Plotting Room was accessed from the Battery Plotting Room via another heavy steel door through a 3 ft thick concrete wall.



Fortress plotting room door

The ceiling was also formed with heavy RSJs set at close centres, cast into the concrete as the steel reinforcement of the roof slab and as the underside of the ceiling. Fresh air intakes were again located at low level around the sides of the room.



Fortress plotting room with graffiti

Galvanised sheet metal ducting for return air in fortress plotting room

Emergency escape

The emergency escape route from the Battery Plotting Room had to bypass the low-level perimeter service duct.

Escape passage from battery plotting room

The entrance into the escape route was therefore through a square metal plate door set into the wall at a position well above the floor level of the Plotting Room. Sets of metal rungs were let into the concrete wall adjacent to the door to facilitate easier access into the narrow escape passage. Similar metal rungs were mounted on the adjacent wall within the escape passage for the same purpose.

Escape passage looking towards escape shaft

A sheet metal exhaust duct was mounted on the underside of the escape passage ceiling. Communication and power cables were also originally mounted on the walls.

The escape route led to a narrow vertical escape shaft with a ladder mounted onto the east wall, now removed. Communication and power cables were mounted on the west wall of the escape shaft and exited a short distance below the top of the shaft.

View up escape shaft

The escape shaft was capped with a heavy steel cover with two brackets fixed to a cable and pulley system in turn connected to two suspended weights in tubes at the base of the shaft to provide mechanical assistance in lifting the heavy cover. Presumably the cover was secured from within by a simple sliding catch.

The underground Plotting Rooms were closely associated with the defence of Table Bay and Cape Town during World War II, and during the immediate postwar period when Robben Island was used as a Military Training Base. They enabled the proper functioning and operation of the two Robben Island batteries and communication with other batteries on the mainland.

Heritage value

This underground complex is a good example of specialised coastal defence architecture and reinforces the character of the historically important WWII era on Robben Island. The choice of construction materials and the robust detailing relate closely to the other concrete structures built for the military on the island.

The Plotting Room facility's heritage value lies in its historical associations with World War II and in particular with the Artillery Specialist Women's Auxiliary Army Service (ASWAAS). It is an example of an unusual, well preserved underground structure designed for a particular purpose and specific function and is a significant heritage building on Robben Island. There are only three other similar facilities in South Africa, namely at Apostle Battery (Llandudno), Scala Battery (Simon's Town) and Da Gama Battery (Bluff, Durban).

Appreciation

The author, William Martinson, is a conservation architect and heritage practitioner, employed by Osmond Lange Architects in the city of East London in South Africa. He completed his Bachelor Degree and a Masters in Architectural Conservation at the University of the Witwatersrand in Johannesburg. William was involved in the Robben Island Built Environment Conservation Manual project and his specific interest in documenting and recording unusual historic structures prompted him to document, draw up and describe the Underground Plotting Room in additional detail.

The assistance of Chris Dooner (ex-SA Navy) in documenting the Plotting Room bunker is acknowledged with grateful thanks. Chris showed the author around Robben Island and identified the site of the underground Plotting Rooms. He then willingly assisted with the interpretation of the drawings and shared his understanding of the different spaces. Jens Kuhn willingly assisted with the measuring-up process.

We are grateful to William for sharing his painstaking and fascinating work with Subterranea Britannica.

All photos by William A Martinson except WWII photo.

HARECASTLE
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Harecastle Tunnel
Opening Hours

EMERGENCY